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Draft Remedial Investigation/Feasibility Study Work Plan for the 1100-EM-1 Operable Unit Hanford Site, Richland, Washington

Environmental Engineering Group

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ACRONYMS AND ABBREVIATIONS

AA	atomic absorption
ADI	acceptable daily intakes
Agreement	consent order and compliance agreement between the EPA, DOE, and Ecology
AIC	acceptable intake for chronic exposure
AIS	acceptable intake for subchronic exposure
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	contract laboratory program
CpF	carcinogenic potency factor
CRQL	contract-required quantitation limits
DMS	data management system
DOE	U.S. Department of Energy
DQO	data quality objective
ECD	electron capture detector
Ecology	Washington Department of Ecology
ECTS	Environmental Compliance Tracking System
EIS	Environmental Impact Statement
EP	extraction procedure
EPA	U.S. Environmental Protection Agency
FID	flame ionization detector
FS	feasibility study
GC	gas chromatography
HASP	health and safety plan
HECR	Hanford Environmental Compliance Report
HEIS	Hanford Environmental Information System
HISS	Hanford inactive site survey
ICP	inductively coupled plasma
LEL	lower explosive limit
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCS	management control system
MS	mass spectroscopy
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission

OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PDMS	Programmable Data and Management System
PJSP	pre-job safety plan
PMP	project management plan
PNL	Pacific Northwest Laboratory
QA	quality assurance
QC	quality control
RA	remedial action
RCR	review comment record
RCRA	Resource Conservation and Recovery Act
RDR	remedial design report
RI	remedial investigation
ROD	record of decision
SAP	sample and analysis plan
SARA	Superfund Amendment and Reauthorization Act
SMCL	secondary maximum contaminant level
SSO	site safety officer
TOC	total organic carbon
TOX	total organic halogen
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
WAC	Washington Administrative Code
Westinghouse	
Hanford	Westinghouse Hanford Company
WIDS	Waste Information Data System

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This work plan was initiated and prepared in accordance with U.S. Environmental Protection Agency (EPA) guidance as stated in Guidance on Remedial Investigations Under CERCLA (EPA 1985d) and Guidance on Feasibility Studies Under CERCLA (EPA 1985c). It provides a description of the tasks required to complete the remedial investigation and feasibility study (RI/FS), which will identify appropriate remedial actions (RA) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendment and Reauthorization Act of 1986 (SARA). Tables 1-1 and 1-2 provide a general outline for RI/FS work plans that is consistent with more recent regulatory guidance (EPA 1988a). The tables indicate the section of this work plan where the information indicated can be obtained. This work plan is intended to address investigation and remediation of inactive waste sites within the 1100-EM-1 operable unit in the proposed 1100 National Priorities List (NPL) Aggregate Area. Additional RI/FS work plans will be prepared to address other operable units.

This work plan also conforms, in part, with the Council on Environmental Quality (CEQ) requirements (CEQ 1978) promulgated under the National Environmental Policy Act of 1970 (NEPA). This work plan, the results of work performed pursuant to it, and subsequent RA decisions will be circulated for public and Federal and State agency review to satisfy CEQ procedural requirements. This work plan is based on the assumption that complete conformance with CEQ requirements will be achieved through the development of a supplemental, programmatic environmental impact statement (EIS). The programmatic EIS, which will encompass all CERCLA activities on the Hanford Site, will address those environmental factors that are not normally relevant to an RI/FS. Such factors include assessing cumulative impacts, impacts on energy and natural resources, transportation, and public services and utilities for the Hanford Site.

In addition to the programmatic EIS, the NEPA process will be applied for each individual operable unit before the initiation of RI work to ensure that potential impacts to workers, the public, and the environment are mitigated while gathering data. Similarly, based on the data gathered during RI, a NEPA review will be completed for the proposed remedial action identified in the Phase III FS.

The primary focus of this work plan is on the initial phase of the RI. Because of the nature of the RI/FS process, the work plan is anticipated to be revised as required to reflect an improved understanding of site conditions and waste characteristics obtained as the RI progresses and to accommodate data needs identified during the FS.

Table 1-1. Generic Outline for Remedial Investigation and Feasibility Study Work Plans With Corresponding Section in 1100-EM-1 Work Plan Indicated.

Outline ^a	Location in this document
Introduction	Section 1.0
Site background and setting	Sections 2.0, 4.1, and Appendix A
Initial evaluation	Section 4.4 and Appendix B
Work plan rationale	Section 4.3
Remedial investigation/feasibility study tasks	Section 7.0
Costs and key assumptions	Section 7.2
Schedule	Section 3.5
Project management	Section 3.0
References	Section 10.0

^aEPA 1988a.

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1.2 BACKGROUND

Over 1,400 waste sites have been identified on the Hanford Site. These include active treatment, storage, and disposal (TSD) facilities, subject to permit application and/or closure under the Resource Conservation and Recovery Act of 1976 (RCRA) and the Dangerous Waste Regulations, Washington Administrative Code (WAC) 173-303 (Ecology 1987a), as well as inactive waste sites subject to corrective action under RCRA or RA under CERCLA. Most of these sites are located within four geographic areas on the Hanford Site that are referred to as the 100, 200, 300, and 1100 Aggregate Areas. Figure 1-1 shows the location of these areas. Each area is subdivided into operable units on the basis of waste disposal practices, geology, hydrogeology, and other pertinent site characteristics. More than 70 operable units have been identified to date. This process is continuing, and the total number of operable units, as well as the individual sites within each operable unit, are subject to change. The listing of operable units and a description of how individual waste sites are organized into operable units is contained in an operable units report now in preparation.

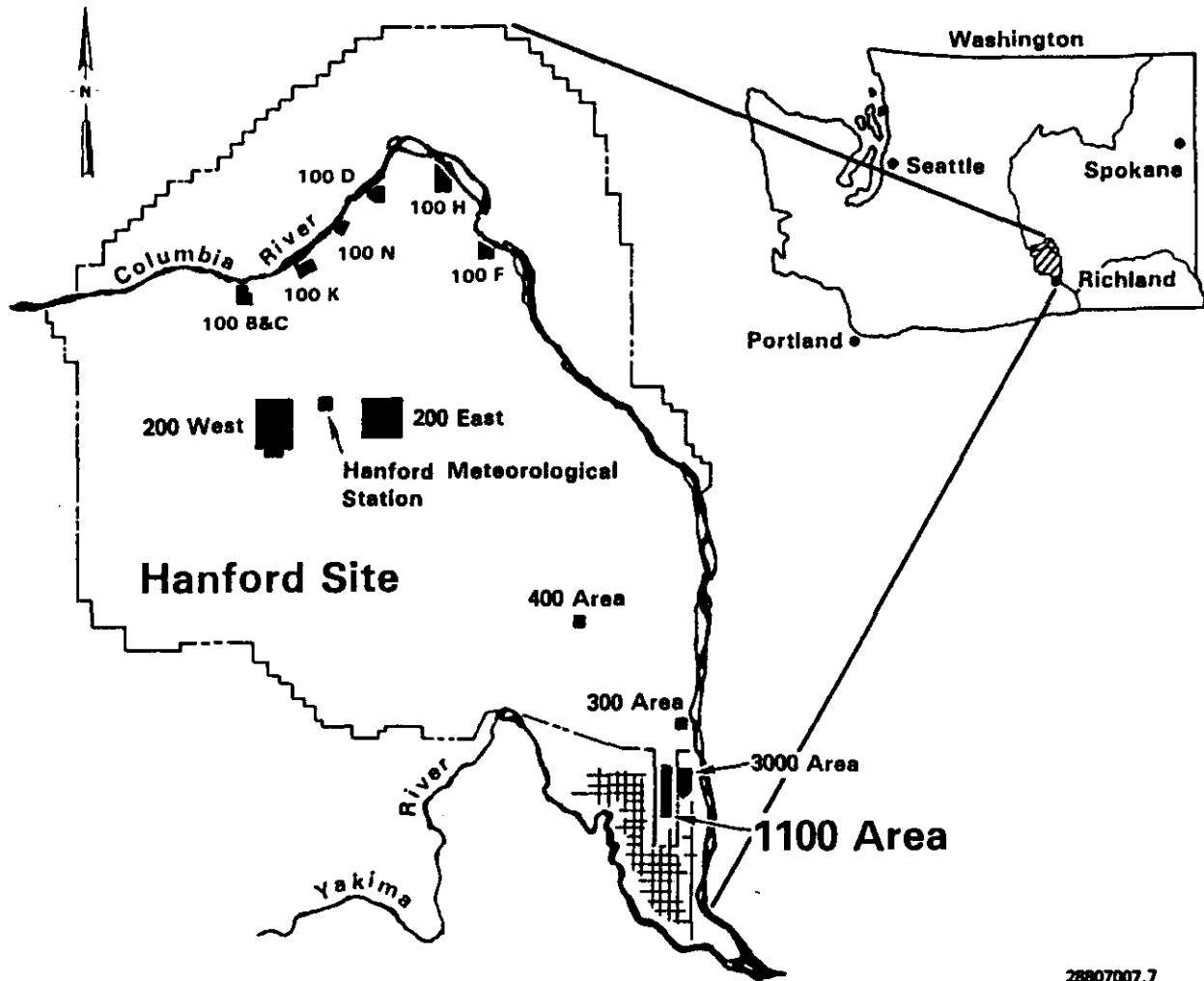
The 1100 Area is the location of vehicle maintenance operations and warehouse facilities that support activities at the Hanford Site. Little specific information is available regarding past waste disposal practices in the 1100 Area. The 1100 Area is located approximately 0.5 mi west of the north Richland well field, which constitutes a significant source of drinking water for the city of Richland. The potential threat to public water supplies is considered the primary justification for NPL inclusion of the 1100 Aggregate Area.

Table 1-2. Generic Outline for Remedial Investigation and Feasibility Study Quality Assurance Plan and Sampling and Analysis Plan With Corresponding Section in 1100-EM-1 Work Plan Indicated.

Outline ^a	Location in this document
Sampling and Analysis Plan	
Site background	Section 4.1
Sampling objectives	Section 4.2
Sample location and frequency	Section 4.4
Sample designation	Section 4.4
Sampling equipment and procedures	Section 4.4
Sample handling and analysis	Section 4.4
Quality Assurance Plan	
Project description	Section 5.2
Project organization and responsibilities	Section 5.2
Quality assurance objectives for measurement	Section 5.3
Sampling procedures	Section 5.4
Sample custody	Section 5.4.2
Calibration procedures	Section 5.5
Analytical procedures	Appendix D
Data reduction, validation, and reporting	Section 5.7
Internal quality control	Sections 5.6 and 5.8
Performance and systems audits	Section 5.8
Preventive maintenance	Section 5.5
Data assessment procedures	Section 5.7
Corrective actions	Section 5.8.4
Quality assurance reports	Section 5.8.3

^aEPA 1988a.

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Figure 1-1. Hanford Site Map.

The 1100 Aggregate Area is subdivided into three operable units. These are designated as Liquid Disposal (1100-EM-1), Active Maintenance (1100-EM-2), and Hazardous Waste Staging (1100-EM-3). Figure 1-2 shows the location of various 1100 Area waste sites. Both 1100-EM-2 and 1100-EM-3 appear to have released relatively little or no hazardous material to the environment and are assigned a low priority. However, the 1100-EM-1 operable unit may have received significant volumes of battery acid, paint and paint thinner, antifreeze, hydraulic fluids, waste oils, and various solvents. Therefore, it has been assigned a relatively high priority because of the proximity to public water supply wells.

1.3 OVERVIEW OF THE REMEDIAL INVESTIGATION AND FEASIBILITY STUDY PROCESS

A consent order and compliance agreement between the EPA, the U.S. Department of Energy (DOE) and the State of Washington Department of Ecology (Ecology) is under negotiation (hereafter referred to as the agreement). This work plan discusses how the investigation and remediation of the 1100-EM-1 waste sites will be conducted under CERCLA and the terms of the agreement.

The ultimate goal of the CERCLA program at the Hanford Site is to select and implement a cost-effective remedial alternative that mitigates threats to, and provides protection of, public health, welfare, and the environment, consistent with regulatory requirements and guidelines established by the EPA and Ecology.

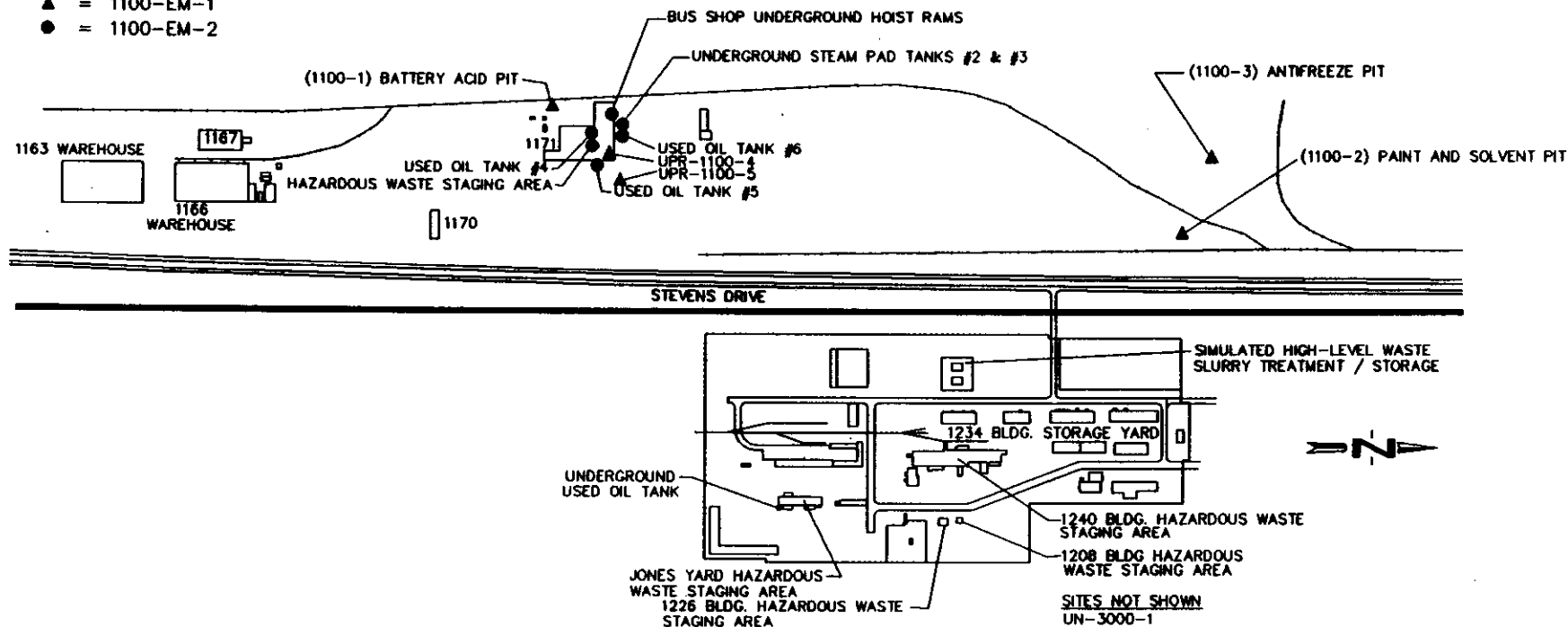
After a waste site has been listed on the NPL, an RI/FS is carried out to determine the nature and extent of the threat posed by hazardous substances, to screen proposed remedial technologies, and to evaluate appropriate remedial alternatives on the basis of effectiveness, ability to implement, and cost. After public review and comment, EPA, with input from Ecology, will select an appropriate remedy and document this choice in a record of decision. This will be followed by design and implementation of the selected alternative. Figure 1-3 indicates the overall RI/FS process. Because relatively little information is available for the 1100 Area, provisions are included for terminating the RI/FS process at an individual site if no contaminants are found or if maximum present or projected contaminant concentrations are below allowable levels. However, at least some of the sites in the 1100-EM-1 operable unit are anticipated to require remediation.

Primary objectives of the RI are to collect onsite data and waste characteristics, assess contaminant pathways and transport mechanisms, and conduct treatability testing as necessary to support the evaluation of proposed remedies. The FS identifies, screens, and evaluates potential remedial alternatives. Data are collected during the RI to support the development of remedial alternatives in the FS, which in turn affects the data needs and scope of subsequent investigations. The RI and the FS are conducted concurrently in several phases. Data collected in the initial phase of the RI are used to develop a general understanding of the site,

1100-EM-1 / 1100-EM-2

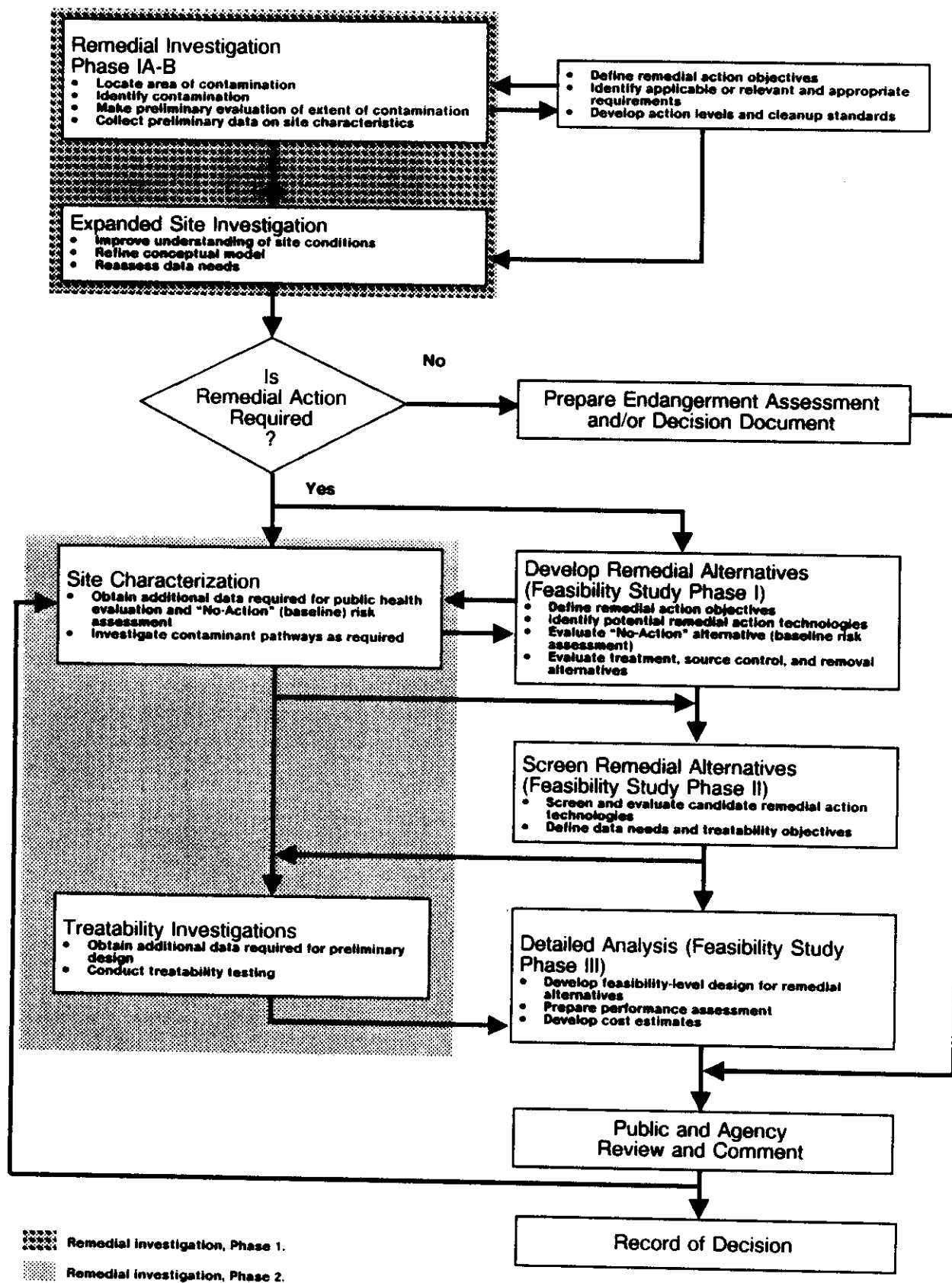
LEGEND

- ▲ = 1100-EM-1
- = 1100-EM-2



1100-EM-3

Figure 1-2. 1100 Area Operable Units.



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Figure 1-3. Remedial Investigation/Feasibility Study Process.

improve the conceptual model derived from existing data, and provide a preliminary assessment of the nature and extent of any contamination. The initial phase of the FS identifies potential RA and determines the threat to public health and the level of risk associated with no action. Subsequent phases of the RI will satisfy specific data needs identified in the FS. Later phases of the FS will include screening of remedial alternatives and feasibility-level design and cost estimates for appropriate remedial alternatives.

The initial phase of the RI/FS will be oriented toward determining the nature and extent of any contamination present in the vicinity of the 1100 Area. If contamination is not present, the results of the initial phase of the RI/FS will be documented in a decision document and submitted for EPA approval, with public review and comment. Additional RI work may be implemented as required to provide adequate assurances that no contamination hazards exist. If contamination is detected, the RI/FS process will be continued to fully define the extent of contamination, assess the hazard to public health or the environment associated with no action, and identify and evaluate appropriate remedial alternatives.

Particularly where groundwater is involved, contamination observed in the vicinity of the 1100 Area may or may not be a result of waste disposal activities associated with the individual waste sites identified as part of the 1100-EM-1 operable unit. Other potential sources of groundwater contamination both within and outside the Hanford Site are known to exist in the vicinity of the 1100 Area. The RI/FS is not intended to investigate these sources specifically. However, the extent to which they contribute contaminants to the groundwater in the 1100 Area will be investigated if necessary.

1.4 WORK PLAN ORGANIZATION

This RI/FS work plan contains seven interrelated plans. These are as follows:

- Project management plan
- Sampling and analysis plan
- Quality assurance plan
- Health and safety plan
- Technology plan
- Data management plan
- Community relations plan.

These plans are included as sections within the work plan as follows:

- Section 2.0 provides a brief description of site conditions and waste disposal at each of the individual waste sites in the 1100 Area.
- Section 3.0 discusses the project management plan. This defines organizational relationships and responsibilities, reporting requirements, and financial and project tracking requirements and presents work plan schedules.
- Section 4.0 discusses the sampling and analysis plan for the 1100 Area. This section also includes a detailed discussion of site background material and describes a conceptual model of contaminant transport mechanisms. The plan defines sampling objectives, data needs, and data quality objectives and provides a description of the sampling and analysis program for each site. The plan provides guidance for the conduct for all field work, coordinates all field activities, and serves as a basis for estimating costs.
- Section 5.0 describes the quality assurance plan, which will ensure that appropriate data of sufficient quality are obtained, that all activities, findings, and results are based on approved, applicable procedures, that all results and analyses are valid and traceable, and that sufficient levels of accuracy, precision, and comparability exist for the data.
- Section 6.0 is the health and safety plan, which describes the policies and procedures that will be implemented to protect workers and the public from potential hazards associated with remedial investigation activities.
- Section 7.0 is the technology plan. This section discusses remedial response objectives, presents criteria for development and screening of remedial alternatives, and outlines the methodology for evaluation of remedial alternatives.
- Section 8.0 discusses the data management plan, which outlines the approach used to ensure that all data generated during the RI/FS are handled and reported in a consistent, traceable, and controlled manner.
- Section 9.0 discusses the community relations plan that will be implemented to provide an established formal means of addressing community concerns and establishing a dialogue between the public and the agencies and contractors involved in the RI/FS.

2.0 SITE DESCRIPTION

The 1100 Area has been used as a maintenance area, warehouse facility, and equipment storage yard in support of operations at the Hanford Site. The 1100 Area is located near the southeastern corner of the Hanford Site (see Figure 1-1). This includes the eastern half of Section 27, the eastern half of Section 22, and the southeast quarter of Section 15, township 10 north, range 27 east, Willamette Standard Meridian. The Horn Rapids landfill, which occupies the northern half of Section 15, has also been included in the 1100 Area. For remediation purposes, the 3000 Area, which lies east of Stevens Drive, is also considered as part of the 1100 Area.

The 1100-EM-3 operable unit consists of waste sites east of Stevens Drive. Although geographically distinct from 1100-EM-1 and 1100-EM-2, these sites may also contain similar wastes. As with 1100-EM-2, they are considered to be active.

For purposes of this investigation, the use of the subject disposal sites is assumed to have been continuous for approximately 30 yr. The types of potentially hazardous waste disposed of at these sites include battery acid, paint, paint thinner, solvents, hydraulic oils, degreasers, and antifreeze. Only limited information regarding disposal practices and site conditions is currently available.

The 1100-EM-1 operable unit includes an abandoned battery acid pit (dry well), two abandoned gravel pits used for waste disposal, the site of a leaking antifreeze tank (since removed), the site of a minor radiation contamination incident, and the Horn Rapids landfill. Note that "Horn Rapids landfill" refers to an abandoned dump site on the southern boundary of the Hanford Site, not the active landfill operated by the city of Richland. Table 2-1 lists individual waste sites and known or suspected contaminants at each site. Figure 2-1 shows the location of each site.

The following is a summary of regional and local conditions relevant to the RI/FS. More detailed information relevant to this 1100 Area operable unit can be found in Appendix A.

The 1100 Area lies on an elongated north-south plateau at an elevation of approximately 400 ft above sea level. The land surface slopes generally to the southwest toward the Yakima River and to the east toward the Columbia River. The area is characterized by southwest-trending sand dunes with low to moderate relief. The dunes are up to 10 ft thick and are largely stabilized by vegetation or have been reworked by grading and excavation for plant facilities.

Surficial deposits consist primarily of eolian sands and silts. These form a veneer of varying thicknesses over the Pasco Gravels and Ringold Formation, which consist primarily of gravel, gravelly sand, sand, and silty sand. The contact between the Pasco Gravels and the Ringold Formation occurs at a depth of approximately 50 ft below ground surface. Occasional interbeds of clay and siltstone occur within the Ringold Formation. Basalts of the Columbia River Basalt Group are present below a depth of approximately 160 to 200 ft below ground surface.

Table 2-1. 1100-EM-1 Operable Unit Waste Sites.

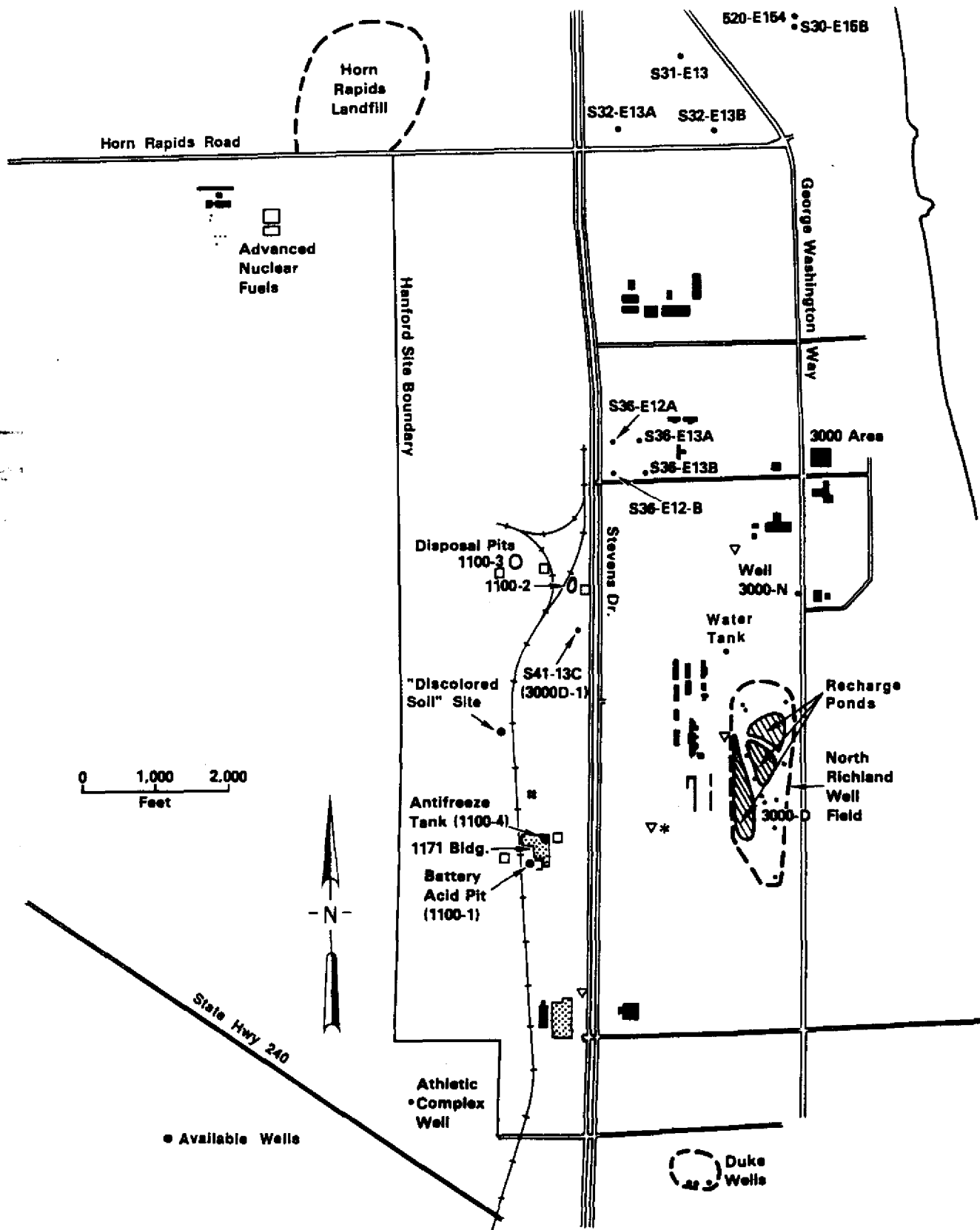
Site identifier	Site name	Service dates	Probable contaminants
1100-1	Battery acid pit	1954 - 1977	Sulfuric acid, lead compounds
1100-2	Paint and solvent pit	1954 - 1985	Paint thinners, solvents, paints
1100-3	Antifreeze and degreaser pit	1979 - 1985	Ethylene glycol, degreasing solvents, wash water from vehicle and equipment cleaning
1100-4	Antifreeze tank site	Pre-1978	Ethylene glycol
UPR-1100-5	Radiation contamination incident	August 24, 1962	Leak of radioactive water onto truck bed, possible ground contamination
Unnumbered	Horn Rapids landfill	Pre-1970	Office and construction wastes, septic tank waste, sewage sludge, fly ash, asbestos materials, carbon tetrachloride, other solvents, paints, etc.
Unnumbered	"Discolored - soil" site	Unknown	Surface spill: possible synthetic organic compounds

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Basalts of the Columbia River Basalt Group are present below a depth of approximately 160 to 200 ft. They are overlain by the Ringold Formation and the Pasco Gravels, which consist primarily of gravel, gravelly sand, sand, and silty sand, with occasional interbeds of clay and siltstone within the Ringold Formation. Eolian sands and silts cover the area as a veneer of varying thickness.

Groundwater occurs in confined aquifers within the basalt sequence, and in the unconfined aquifer of the Pasco Gravels and Ringold Formation. The unconfined aquifer in the area exhibits relatively high permeability, particularly in the Pasco Gravels. Hydrostratigraphic units are subject to lateral variation. Perched or semiperched water conditions may also occur locally. The estimated depth to the water table in the vicinity of the 1100 Area is approximately 50 ft. The boundary between the confined and unconfined aquifers is generally the lowermost silt and clay member of the Ringold Formation.

The regional groundwater flow direction is from west to east. However, there are local perturbations, and the water table in the area of interest is not known in sufficient detail to predict groundwater flow directions at any particular point. Moreover, the direction and velocity of groundwater flow is likely to be time-variant, particularly in the vicinity of pumped wells and/or recharge areas.



2800003.16

Figure 2-1. Waste Site Locations for the 1100-EM-1 Operable Unit.

Available data suggest that infiltration or gaseous diffusion of contaminants through the soil column to the unconfined aquifer is the most credible pathway for contaminant transport to potential receptors. The city of Richland operates recharge ponds and shallow wells tapping the unconfined aquifer in the north Richland well field, which is located approximately 0.5 mi east of the 1100 Area. Therefore, the possibility of groundwater contamination is the primary concern in the 1100 Area.

Annual precipitation is less than evaporation. No permanent or ephemeral streams exit in the vicinity of the sites. Furthermore, the surface characteristics and infiltration capacity of the soil at each site do not lend themselves to dispersal of contaminants directly to surface water via an overland route.

Volatilization or air entrainment of contaminants is not considered likely unless the sites are disturbed. Spread of contamination by direct contact is also considered to be unlikely.

3.0 PROJECT MANAGEMENT PLAN

3.1 INTRODUCTION

The purpose of this project management plan (PMP) is to define the administrative and institutional tasks necessary to support RI/FS activities in the 1100-EM-1 operable unit at the Hanford Site under CERCLA. This plan defines the responsibilities of the various participants, the organizational structure, and the project tracking and reporting procedures.

The EPA, Ecology, and the DOE are entering into an agreement for RA on the Hanford Site. An action plan that will implement this agreement will define EPA and Ecology regulatory integration and the methods and processes to be used to implement the agreement. This PMP is in accordance with the provisions of the action plan. Revisions to the action plan may result in changed requirements that would supersede the provisions of this plan.

3.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

3.2.1 Interface of Regulatory Authorities and the U.S. Department of Energy

The 1100-EM-1 operable unit consists of inactive waste management units to be remedied under CERCLA, as amended by SARA. Therefore, it is under the authority of the EPA. The EPA has been designated as the lead regulatory agency as defined in the agreement. Accordingly, the EPA is responsible for overseeing remedial activity at this unit and ensuring that the applicable authorities of both the EPA and Ecology are applied.

As the lead agency, the EPA will do the following.

- Assign an EPA project manager and a unit manager.
- Coordinate with Ecology as the support agency.
- Review and approve all primary documents prepared by DOE.
- Review and comment on secondary documents, if necessary.
- Evaluate DOE responses to comments.
- Review and approve any action proposal by DOE.
- Draft the record of decision.
- Determine if an interim remedial action is required and request a proposed remedy from DOE, if necessary.

Ecology will be the support agency responsible for assigning an Ecology project manager and unit manager and for reviewing and commenting on all primary documents.

The DOE will do the following.

- Assign a DOE project manager and a unit manager.
- Prepare and implement the RI/FS work plan.
- Perform the Phase I and II RI and the Phase I, II, and III FS.
- Prepare the RI/FS reports.
- Revise documents and respond to comments by the EPA and Ecology.
- Propose appropriate alternatives for an IRA, if required.
- Compile and maintain the administrative record.
- Upon issuance of the record of decision (ROD), prepare the remedial design report (RDR), RA work plan, and operation and maintenance plan.

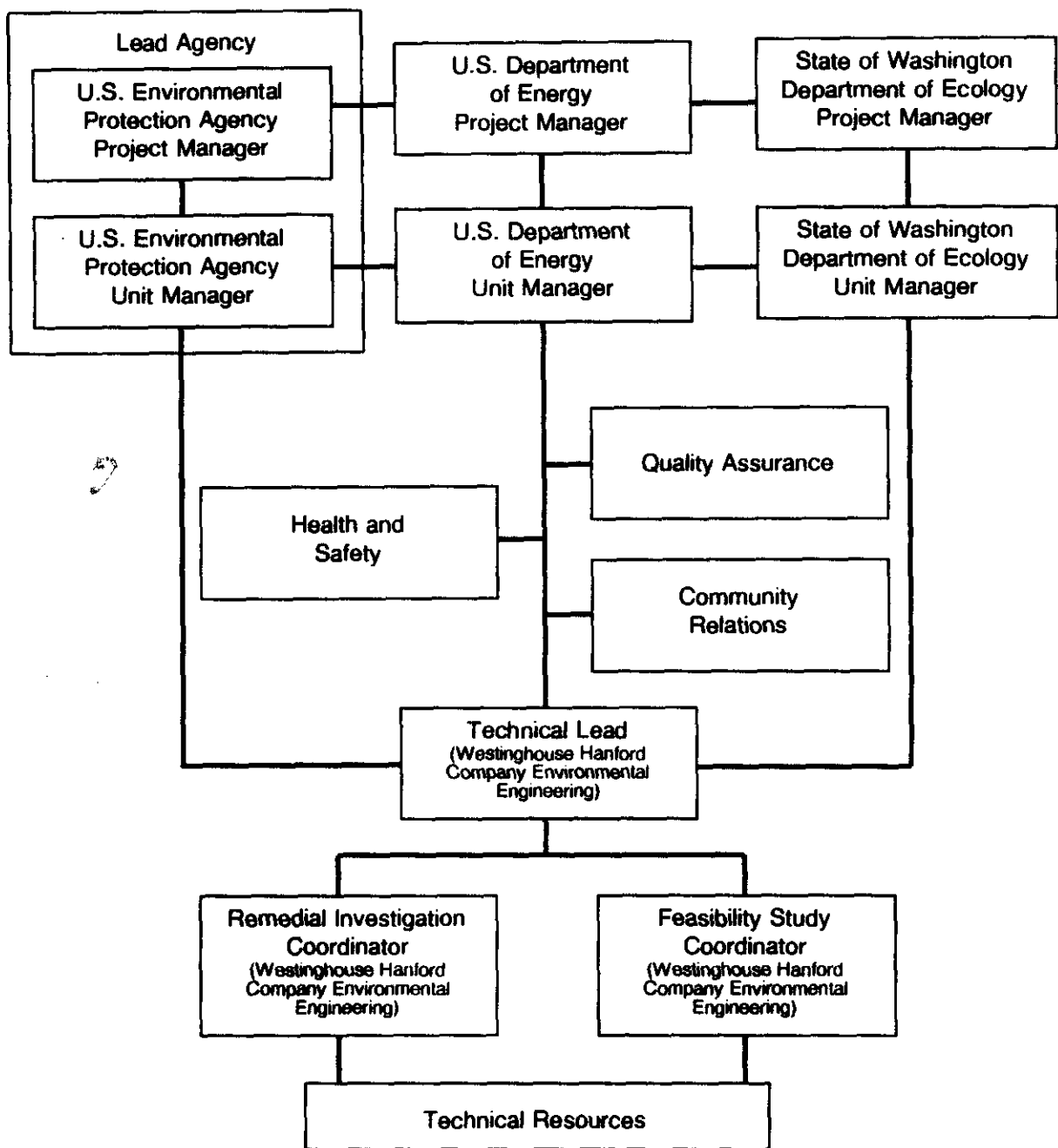
3.2.2 Project Organization and Responsibilities

The top level project organization is shown on Figure 3-1. The following sections describe the responsibilities of the individuals shown on Figure 3-1.

Project Managers. The EPA, DOE, and Ecology will each designate one individual as project manager, who will serve as the primary point of contact for all activities to be carried out under the agreement and action plan. In addition, each of the above three parties will designate an alternate project manager. The primary responsibilities of the project managers are as follows.

- Implement the scope, terms, and conditions of the action plan.
- Direct and provide guidance to unit managers.
- Maintain effective communications among each other.
- Report project status to their respective management.
- Approve any changes to schedules in the work plan that will impact the work schedule contained in the action plan.

The DOE Project Manager will be responsible for maintaining a listing of the current unit managers.



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Figure 3-1. Project Organization.

Unit Managers. The EPA, DOE, and Ecology will each designate a unit manager for this RI/FS; the unit manager from EPA will serve as the lead unit manager. The lead unit manager will be responsible for the activities required by the 1100-EM-1 operable unit RI/FS work plan. The unit managers will represent their respective parties for these activities and are responsible for keeping their respective project managers informed on the work status, budget, and schedule, and of any problems that may arise.

Technical Lead. The technical lead will be a designated person within the Westinghouse Hanford Environmental Engineering Group. The responsibilities of the technical lead will be to plan, authorize, and control work so that it can be completed on schedule and within budget, and to ensure that all planning and work performance activities are technically sound.

Remedial Investigation Coordinator. The RI coordinator will be responsible for coordinating all activities related to Phases I and II of the RI, including data collection, analysis, and reporting. The RI coordinator will be from the Westinghouse Hanford Environmental Engineering Group, and will be responsible for keeping the technical lead informed on the RI work status and any problems that may arise.

Feasibility Study Coordinator. The FS coordinator will be responsible for coordinating all activities related to Phases I, II, and III of the FS, including data collection, analysis, and reporting. The FS coordinator will be from the Westinghouse Hanford Environmental Engineering Group, and will be responsible for keeping the technical lead informed on the FS work status and any problems that may arise.

Remedial Investigation Technical Resources. The various technical resources responsible for performing the RI are shown on Figure 3-2. These resources will be responsible for performing data collection, analysis, and reporting for the technical activities related to the RI. Figures 3-3 and 3-7 show detailed organizational structure for specific RI tasks.

Internal and external work orders and subcontractor task orders will be written by the RI coordinator to use these technical resources, which are under the control of the technical lead. Statements of work will be provided that will include a discussion of authority and responsibility, a schedule with clearly defined milestones, and a task description including specific requirements. Each group will keep the RI coordinator informed on the RI work status performed by that group and of any problems that may arise.

Feasibility Study Technical Resources. The various technical resources responsible for performing the FS are shown on Figure 3-2. These resources will be responsible for identifying and screening remedial alterations, and for detailed evaluation of selected alternatives. Work teams reporting to the technical lead for various phases and types of work are shown in Figures 3-3 through 3-7.

Figure 3-2. Technical Resources for Conducting Remedial Investigations/Feasibility Studies.

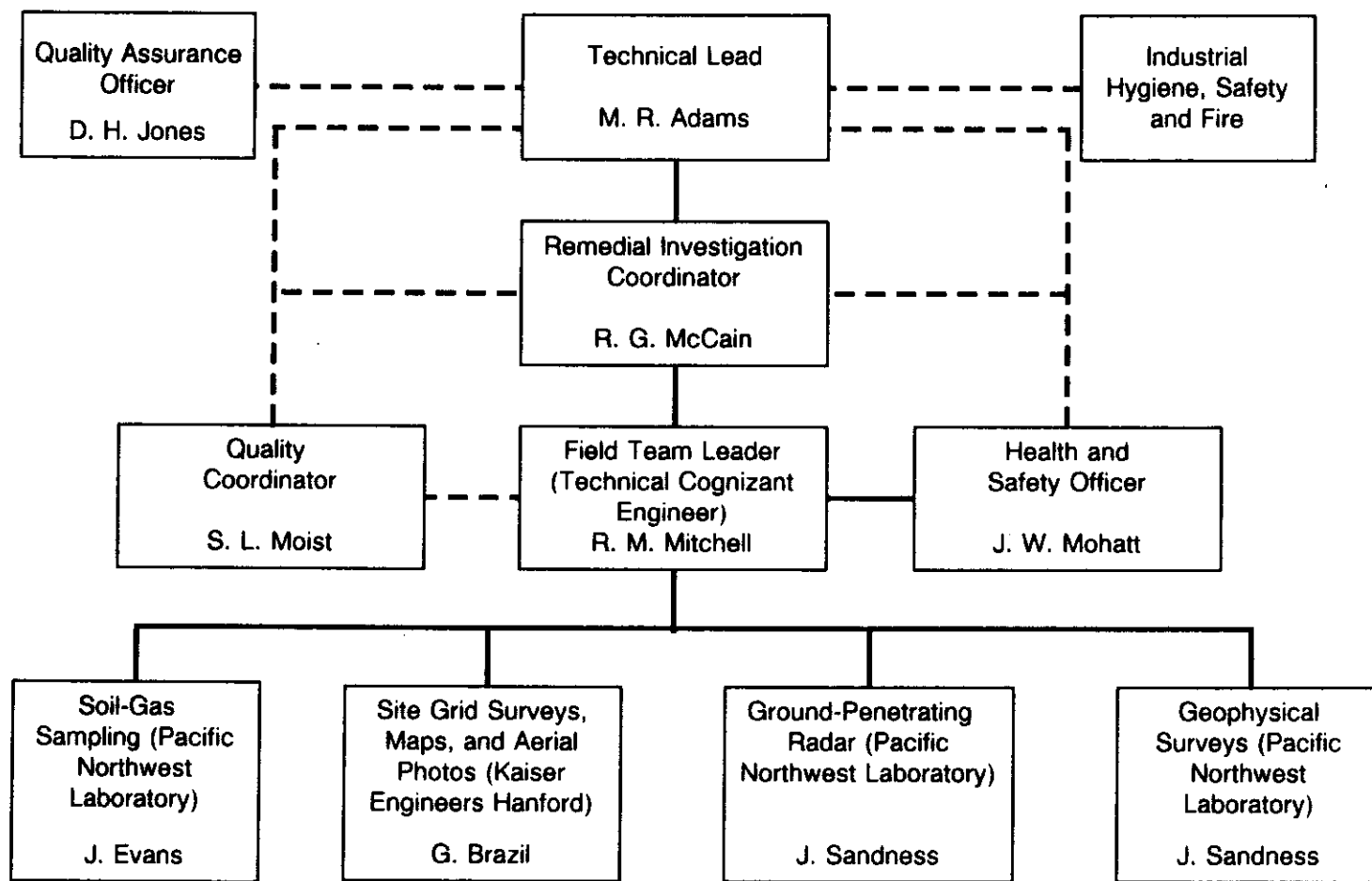
Technical Resources		
Subject/Activity	Remedial Investigation	Feasibility Study
Hydrogeology and geology	Westinghouse Hanford ^a /Geosciences PNL ^b /Earth and Environmental Sciences Center	Westinghouse Hanford/ Geosciences
Toxicology and risk/ endangerment assessment	Westinghouse Hanford/ Environmental Technology PNL/Earth and Environmental Sciences Center PNL/Life Sciences Center	Westinghouse Hanford/ Environmental Technology
Environmental chemistry	Westinghouse Hanford/Geosciences PNL/Earth and Environmental Sciences Center	Westinghouse Hanford/ Geosciences
Geophysics and field testing	Westinghouse Hanford/Geosciences (Planning) Environmental Field Services	N/A
Geotechnical and civil engineering	N/A	Westinghouse Hanford/ Environmental Engineering and PNL/Waste Technology Center
Groundwater treatment engineering	N/A	Westinghouse Hanford/ Environmental Engineering and PNL/Waste Technology Center
Waste stabilization and treatment	N/A	Westinghouse Hanford/ Environmental Engineering and PNL/Waste Technology Center
Surveying	Kaiser Engineers	N/A
Soil and water sampling and analysis	Westinghouse Hanford/Environmental Engineering and Geosciences Environmental Field Services PNL/Earth and Environmental Sciences Center PNL/Materials and Chemical Sciences Center U.S. Testing	N/A
Drilling and well installation	Westinghouse Hanford/Geosciences Environmental Field Services Kaiser Engineers	N/A
Radiation monitoring	Westinghouse Hanford/Operational Health Physics	N/A

NOTE: Qualified subcontractors may conduct all or portions of the RI/FS.

^aWestinghouse Hanford = Westinghouse Hanford Company.

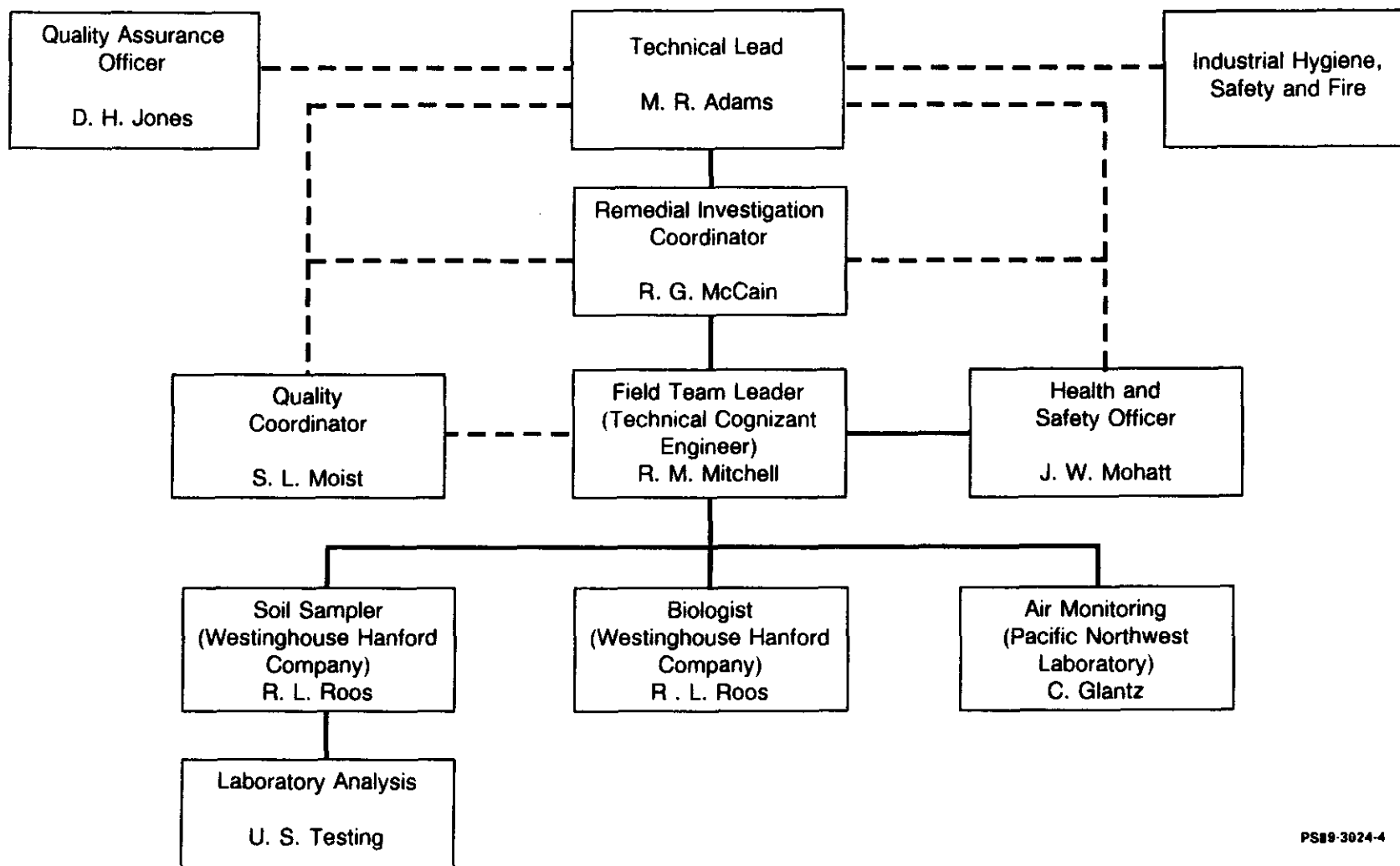
^bPNL = Pacific Northwest Laboratory.

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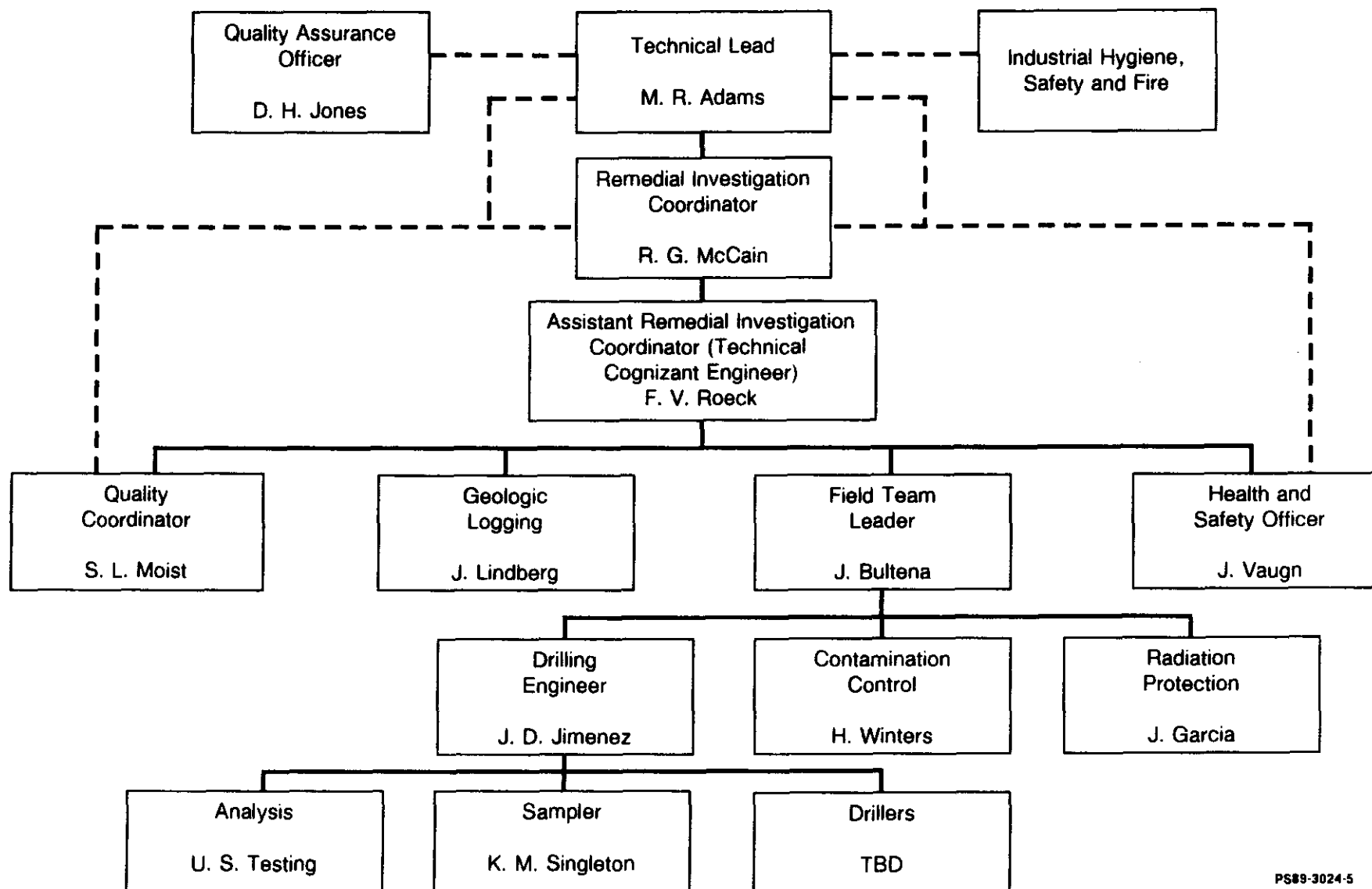
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Figure 3-3. 1100-EM-1 Physical and Geophysical Survey Team.



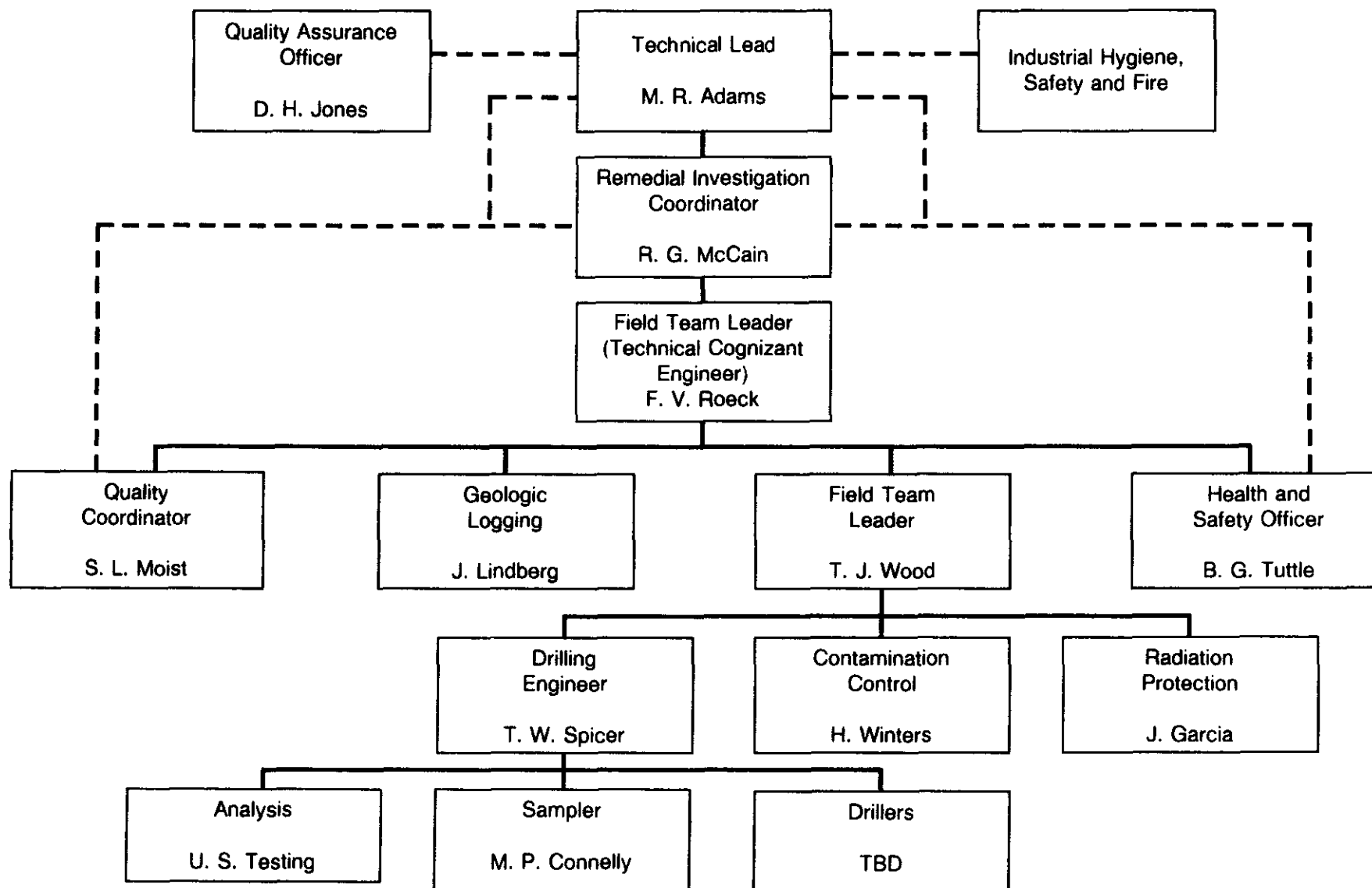
PS89-3024-4

Figure 3-4. 1100-EM-1 Biotic, Air, and Soil-Sampling Team.



PS89-3024-5

Figure 3-5. 1100-EM-1 Vadose Zone Drilling and Sampling Team #1.



PS89-3024-6

Figure 3-6. 1100-EM-1 Vadose Zone Drilling and Sampling Team #2.

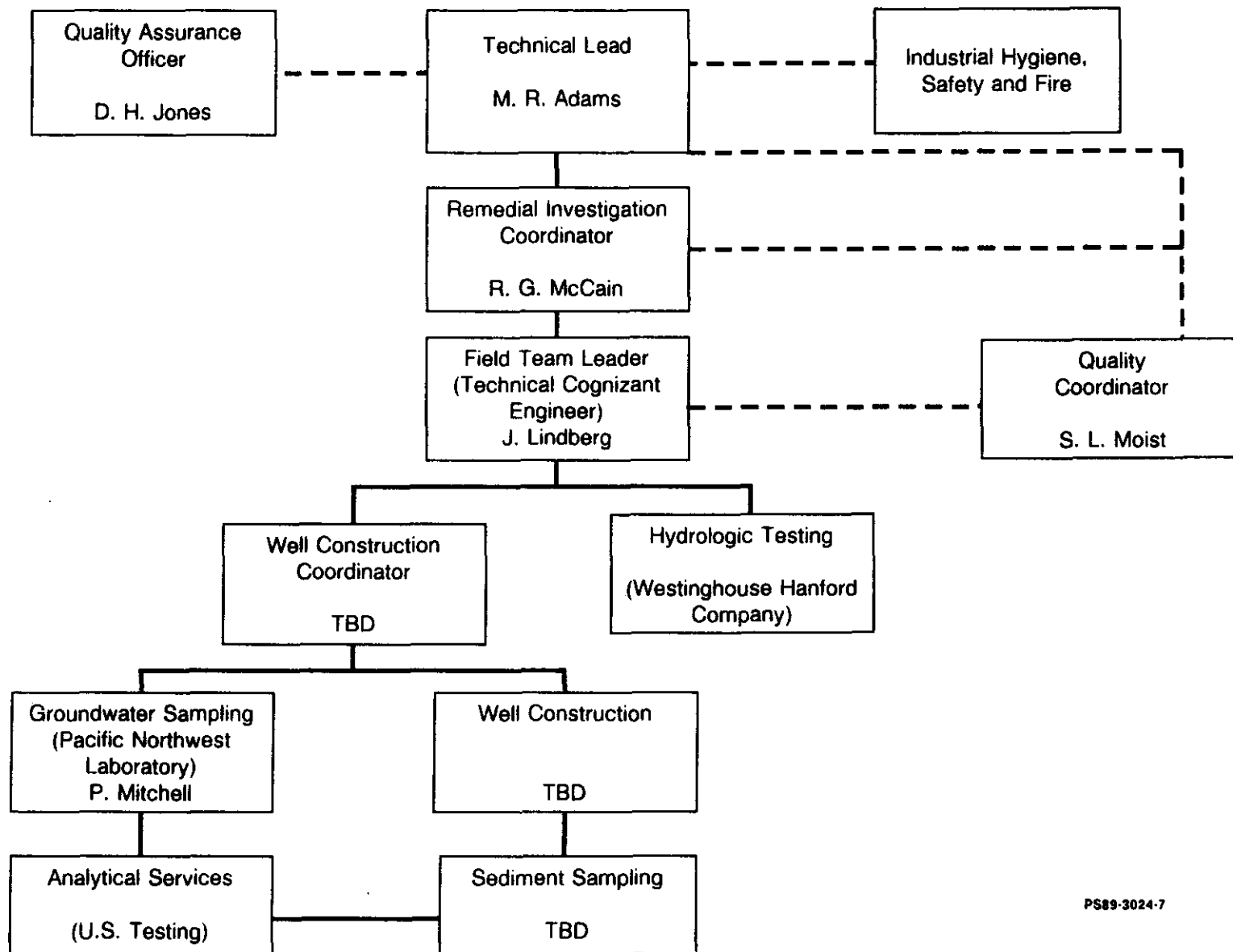


Figure 3-7. 1100-EM-1 Groundwater Well Construction and Hydrologic Testing Team.

Internal and external work orders and subcontractor task orders will be written by the FS coordinator to use these technical resources, which are under the control of the technical lead. Statements of work will be provided that will include a discussion of authority and responsibility, a schedule with clearly defined milestones, and a task description including specific requirements. Each group will keep the FS coordinator informed on the FS work status performed by that group and of any problems that may arise.

3.3 REPORTING REQUIREMENTS

3.3.1 Categorization of Documents

All documents will be categorized as either primary or secondary. Primary documents, which are managed by the EPA and DOE, represent the final documentation of key data and reflect decisions on how to proceed. Primary documents include the following:

- The RI/FS work plan
- The RI Phase II report
- The FS Phase I and II report
- The FS Phase III report
- The proposed plan.

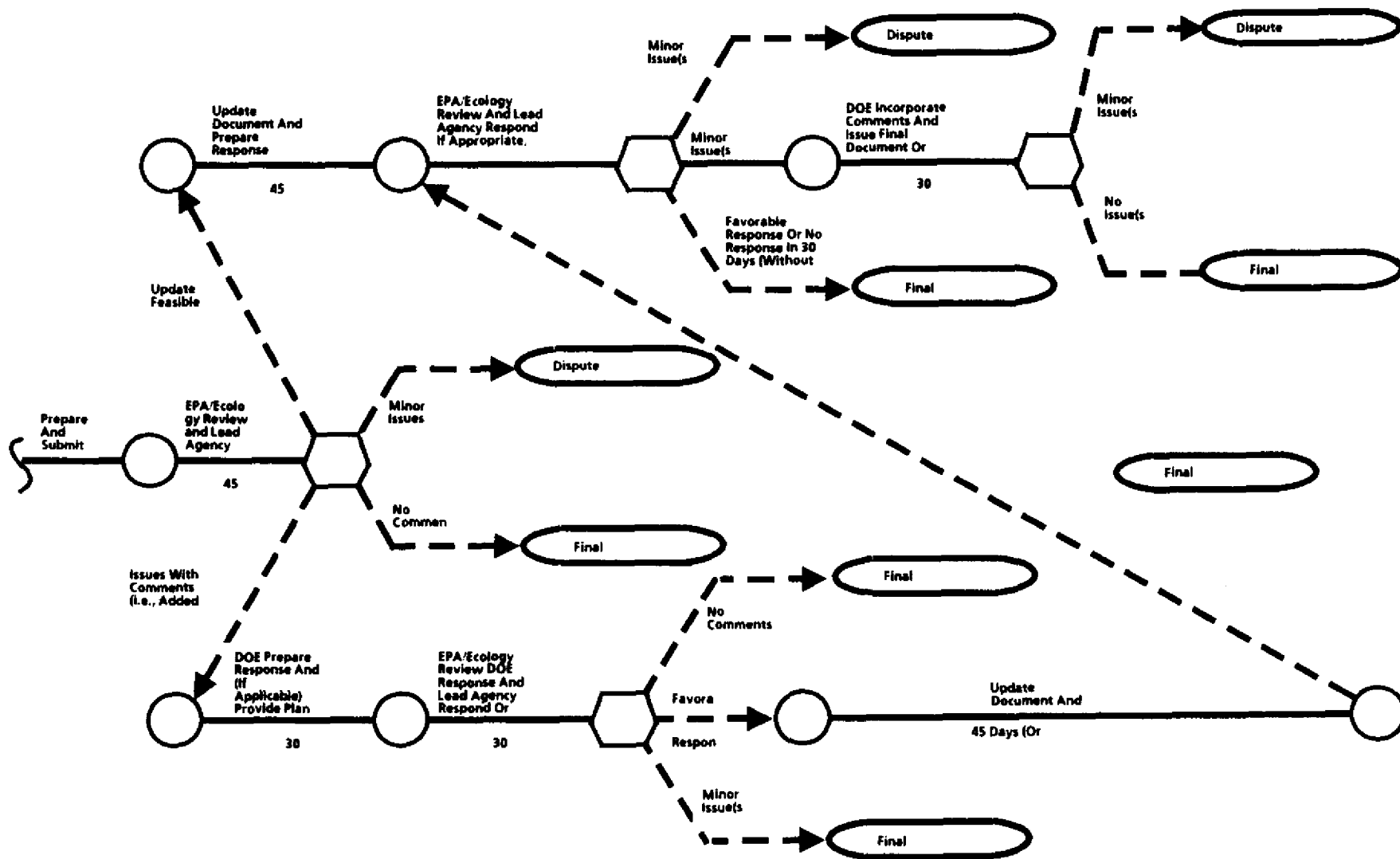
Secondary documents represent an interim step in a decision-making process or are issued for information and do not reflect key decisions. Secondary documents include the following:

- The RI Phase I report
- Sampling and data results
- Supporting studies and analyses
- Other supporting documents, as necessary.

3.3.2 Document Review and Comment

3.3.2.1 Primary Documents. Figure 3-8 provides the process flow for reviewing and commenting on primary documents. The flowchart reflects the multiple paths that a primary document may take depending on the type and extent of comments received. Figure 3-8 also designates the time periods, in terms of days, for specific actions.

All comments shall be submitted on a review comment record (RCR) (Figure 3-9). The RCR will provide a record of the comment, together with the disposition, as agreed to by both the reviewer and the preparer. Comments may be made on all aspects of the document, including completeness,



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Figure 3-8. Review and Comment on Primary Documents.

REVIEW COMMENT RECORD (RCR)				1 Date	2 Review No
				3 Project No.	4 Page 1 of ____
5 Document Number(s)/Title(s)		6 Program/Project/Building Number	7 Reviewer	8 Organization/Group	9 Location/Phone
17 Comment Submittal Approval _____ Reviewer		10 Agreement with indicated comment disposition(s) _____ Reviewer _____ Date _____ Project/Cognizant Engineer		11 CLOSED _____ Reviewer _____ Date _____ Project/Cognizant Engineer	
12 Item	13 Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated)	14 Hold Point	15 Disposition (provide justification if NOT accepted).		16 Status

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Figure 3-9. Review Comment Record.

and should include, but are not limited to, technical adequacy and consistency with CERCLA or other pertinent guidance or policy. Where possible, comments shall be specific to individual lines, paragraphs, or sections. All comments shall be provided with adequate specificity so that DOE can respond in detail and make appropriate changes in the document. Comments shall refer to any pertinent sources of authority or references on which the comments are based, and, upon request of DOE, the commenting agency shall provide a copy of the cited authority or reference. In cases involving complex or unusually lengthy documents, the EPA may extend the comment period for an additional period by written notice to DOE prior to the end of the first period. On or before the close of the comment period, EPA shall transmit their written comments by next-day mail to the DOE unit manager. Within 1 d of receiving EPA comments the DOE unit manager will transmit them to the technical lead.

Representatives of the DOE shall make themselves readily available to the EPA during the comment period for the purpose of informally responding to questions and comments. Oral comments made during such discussions need not be the subject of a written response by DOE but will be addressed as appropriate.

In commenting on a draft document that contains a proposed applicable or relevant and appropriate requirements (ARAR) determination, the EPA shall include a reasoned statement of whether or not they object to any portion of the proposed ARAR determination. To the extent that the EPA does object, it shall explain the basis for its objection in detail and shall identify any ARARs that it feels were not properly addressed in the proposed ARAR determination.

Upon receiving the comments from the EPA, DOE will update the document and/or respond to the written comments. The response will include a schedule for obtaining additional information if required. The DOE may extend the period for responding to the comments by obtaining written approval from the EPA.

Upon receiving the responses to the comments, the EPA will complete its evaluation of the response. In the event that the responses are inadequate, the matter will enter the dispute resolution process as set forth in Section XI of the Federal Facility Agreement. The majority of the disputes are anticipated to be resolved during the initial informal dispute resolution period. Within 30 d of completion of the dispute resolution, or of the EPA evaluation of the responses if there is no dispute, DOE will incorporate the resolved comments into the document (see Part III of the Agreement). The DOE may extend the 30-d period for revising the document by obtaining written approval of the EPA if the comments require additional information to be developed.

Upon receiving an updated document (with or without supporting responses), the EPA will determine if the document is adequate. If major issues still exist, the dispute resolution process will be initiated. If the document is adequate or if only minor modifications are necessary, the EPA will notify DOE in writing. If no such notice is received at the end of the 30-d period, the document will become final.

3.3.2.2 Secondary Documents. On secondary documents, EPA and Ecology have the option to provide comments within 45 d of submittal or take no action. Comments will be transmitted via RCR (Fig. 3-9). If comments are provided, DOE will respond in writing within 30 d. The same criteria for review presented above for primary documents will be used for secondary documents. However, secondary documents are not subject to the dispute resolution process.

3.3.3 Revision/Modification of Primary and Secondary Documents

Following finalization, modification of primary or secondary documents may become necessary. Modification of a document shall be required only if the modification could be of significant assistance in (1) evaluating impacts on the public health or the environment, (2) evaluating the selection of remedial alternative, or (3) protecting human health and the environment. Modification may require additional field work, pilot studies, computer modeling, or other supporting technical work. The following criteria must be met to revise a document.

- A party may seek to modify a document after finalization if it determines, based on new information (i.e., information that became available, or a condition that became known, after the document was finalized), that the requested modification is necessary. The party may seek such a modification by submitting a concise written request to the project managers. The request shall specify the nature of the requested modification and the new information on which the request is based.
- Consensus should be reached by the project managers on the need for the modification. In the event that consensus is not reached, any party may invoke dispute resolution to determine if such modification shall be conducted.

Nothing in this section shall alter the EPA's ability to request the performance of additional work that does not constitute modification of a final document. The review and comment process for the document revision will be the same as that for the original document.

3.3.4 Administrative Records

An administrative record shall be established to support the ROD. The administrative record file will contain all of the documentation used to arrive at the ROD; it will be available for public inspection when the investigation process begins. The administrative record file will be maintained in Richland, Washington. There will be two additional copies of the file: one will be at the EPA Region 10 office and one at the Ecology office. The DOE will compile and maintain the file in Richland and will provide copies to the EPA and Ecology for their respective files. The administrative record file will be initiated when the first document relating to the 1100-EM-1 operable unit is submitted to EPA/Ecology. The contents of the file will increase as the process continues. When the decision document

is signed, all documentation relevant to the selection of the final action(s) must be in the file.

The administrative record includes all primary and secondary documents. In addition, it will include the following:

- All EPA, Ecology, and public comments on documents
- All DOE responses to comments
- Documentation of EPA and Ecology evaluation of the responses
- All documentation of dispute resolution activities, including correspondence and final resolutions.

3.3.5 Distribution of Documents and Correspondence

Table 3-1 indicates the appropriate distribution of all documents and correspondence. In general, any correspondence or documents relevant to the evaluation and selection of a remedial alternative will be included in the administrative record.

3.3.6 Change Control

This section provides the process for modifying the work schedule in this work plan, as well as minor field changes, without having to process a formal revision as described in Section 3.3.3.

3.3.6.1 Authority to Approve Changes. Approval of each project manager is required on all changes to the work plan schedules that impact the work schedule contained in the action plan described in Section 3.3.2. Changes to the work plan schedules that do not impact the action plan can be approved by the unit managers.

3.3.6.2 Formal Change Control Process. Changes to the work plan schedule, including those that impact the work schedule in the action plan, shall be processed using the change control sheet included as Figure 3-10.

Changes are tracked by a "change number." The DOE shall maintain a log of all changes by number and title, along with a file copy of the change. An individual will be assigned responsibility for maintaining the change file and will be responsible for assigning change numbers. The change number can be obtained any time during the change process, even after the change is approved.

The change control form should include a short title for the change, which will be used primarily as a cross-reference on the change log. It should also provide a description of the change, along with justification as to why the change should be made, and should briefly explain the likely consequences if the change is not made. All documents that will have to be revised because of the change shall be listed.

Table 3-1. Distribution of Documents and Correspondence.

	Not affecting decisions on remedial actions	Affecting decisions on remedial actions
Unit manager's correspondence	Unit managers for that operable unit at other two agencies Project managers at all three agencies	Unit managers for that operable unit at other two agencies Project managers at all three agencies Administrative Record Files
Project manager's correspondence	Project managers at other two agencies Affected unit managers	Project managers at other two agencies Administrative Record Files
Draft primary or secondary documents Final secondary documents	Unit managers for that operable unit at all three agencies Project managers at all three agencies Administrative Record Files	N/A
Final primary documents	N/A	Unit managers for that operable unit at all three agencies Project managers at all three agencies Administrative Record Files
Quarterly Reports	Unit managers for that operable unit at all three agencies Project managers at all three agencies Administrative Record Files	Unit managers for that operable unit at all three agencies Project managers at all three agencies Administrative Record Files

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Change Number: ①	CHANGE CONTROL SHEET		③
Originator:		②	
Class of Change:			
<input type="checkbox"/> I-Signatories (Section 13.0) <input type="checkbox"/> II-Project Manager <input type="checkbox"/> III-Unit Manager			
Change Title:		⑤	④
Description/Justification of Change:			
⑥			
Impact of Change:			
⑦			
Affected Documents: (List Specific Documents)			
⑧			
Approvals			
_____	_____	⑩	
_____	_____		
_____	_____		
⑨			

Figure 3-10. Change Control Sheet.

3.4 FINANCIAL AND PROJECT TRACKING REQUIREMENTS

3.4.1 Management Control

Westinghouse Hanford will be responsible to plan and control activities and to provide effective technical, cost, and schedule baseline management. The Westinghouse Hanford Management Control System (MCS) will be used for effective planning and control practices. The MCS meets the requirements of DOE Order 4700.1, Project Management System (DOE 1987c), and DOE Order 2250.1B, Cost and Schedule Control Systems Criteria for Contract Performance Measurement (DOE 1985). The primary goals of the Westinghouse Hanford MCS are to provide methods for planning, authorizing, and controlling work so that it can be completed on schedule and within budget and to ensure that all planning and work performance activities are technically sound and in conformance with management and quality requirements.

The work plan schedule and major milestones are described in Section 3.5 of this work plan. The work plan schedule will be the primary vehicle for the unit and technical leads to track progress. The work plan schedule must be consistent with the work schedule contained in the action plan for implementation of the agreement, as discussed in Section 3.2.1 of this work plan.

The work plan schedule will be updated at least annually, with the primary purpose to expand the new current fiscal year and the follow-on year. In addition, any approved schedule changes (see Section 3.3.6 for formal change control system) would be incorporated at this time, if not previously incorporated. This update will be performed in the fourth quarter of the previous fiscal year (e.g., July to September) for the upcoming current fiscal year. The work schedule can be revised at any time during the year if the need arises, but would be restricted to major changes that would not be suitable for the change control process.

3.4.2 Meetings and Progress Reports

3.4.2.1 Project Managers Meeting. The project managers shall meet, at a minimum, on a quarterly basis to discuss progress, address issues, and review plans for the next quarter. A status of the work schedules from selected RI/FS work plans will be reviewed at the meeting and will include any supporting technical information. Any agreements and commitments resulting from the meeting will be prepared and signed by all parties prior to the conclusion of the meeting.

3.4.2.2 Unit Managers Meeting. The unit managers shall meet at least monthly to discuss work progress, address technical issues, and review near-term plans. The DOE unit manager will prepare a monthly status report on the schedules of all ongoing activities from the RI/FS work plan prior to the meeting. The schedule status report will be provided by DOE to all parties and reviewed at the meeting. Any agreements and commitments (within the unit manager level of authority) resulting from the meeting will be prepared and signed by all parties prior to the conclusion of the meeting. The DOE unit manager shall issue the meeting minutes to all parties, with information

copies to the project managers, within 5 working days following the meeting. The minutes will include, as a minimum, the following:

- Status of previous agreements and commitments
- Description of agreements and commitments resulting from meeting
- Work schedule status
- Any approved changes signed off at the meeting in accordance with Section 3.3.6 of this work plan.

3.4.2.3 Quarterly Progress Report. The DOE shall issue a quarterly progress report to the EPA and Ecology within 45 d following the end of the quarter being addressed, for all ongoing work associated with the agreement and action plan. The issuance of these reports will be shown on the action plan. The report shall include the following:

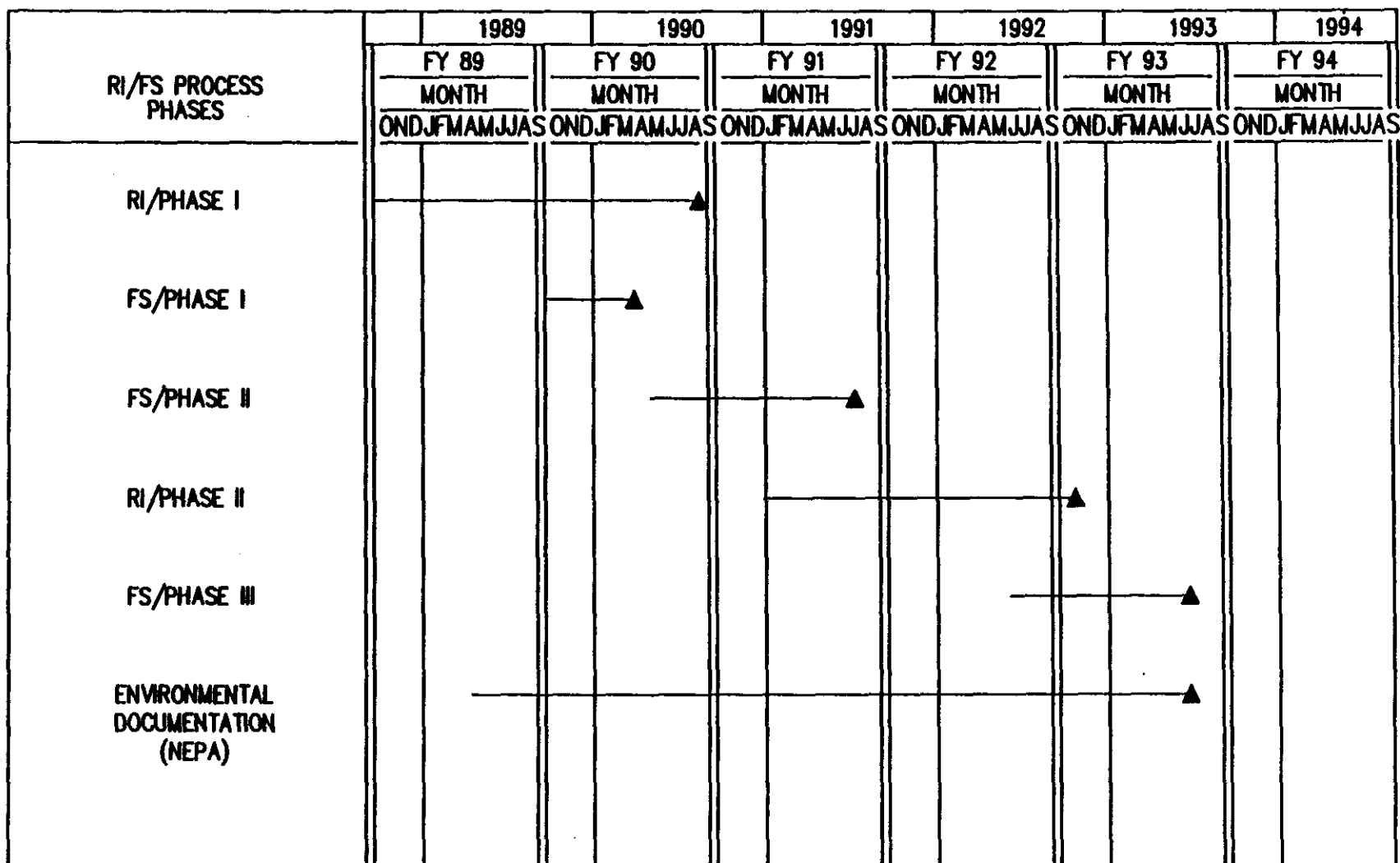
- Highlights of significant progress and problems
- Technical progress, with supporting pictures as appropriate
- Problem areas with recommended solutions
- Significant activities planned for next quarter
- Work schedule status.

Subsequent to review and approval by Defense Program management authority, the fully approved report will be issued to the EPA and Ecology and placed in public reading rooms for public access.

3.5 WORK PLAN SCHEDULES

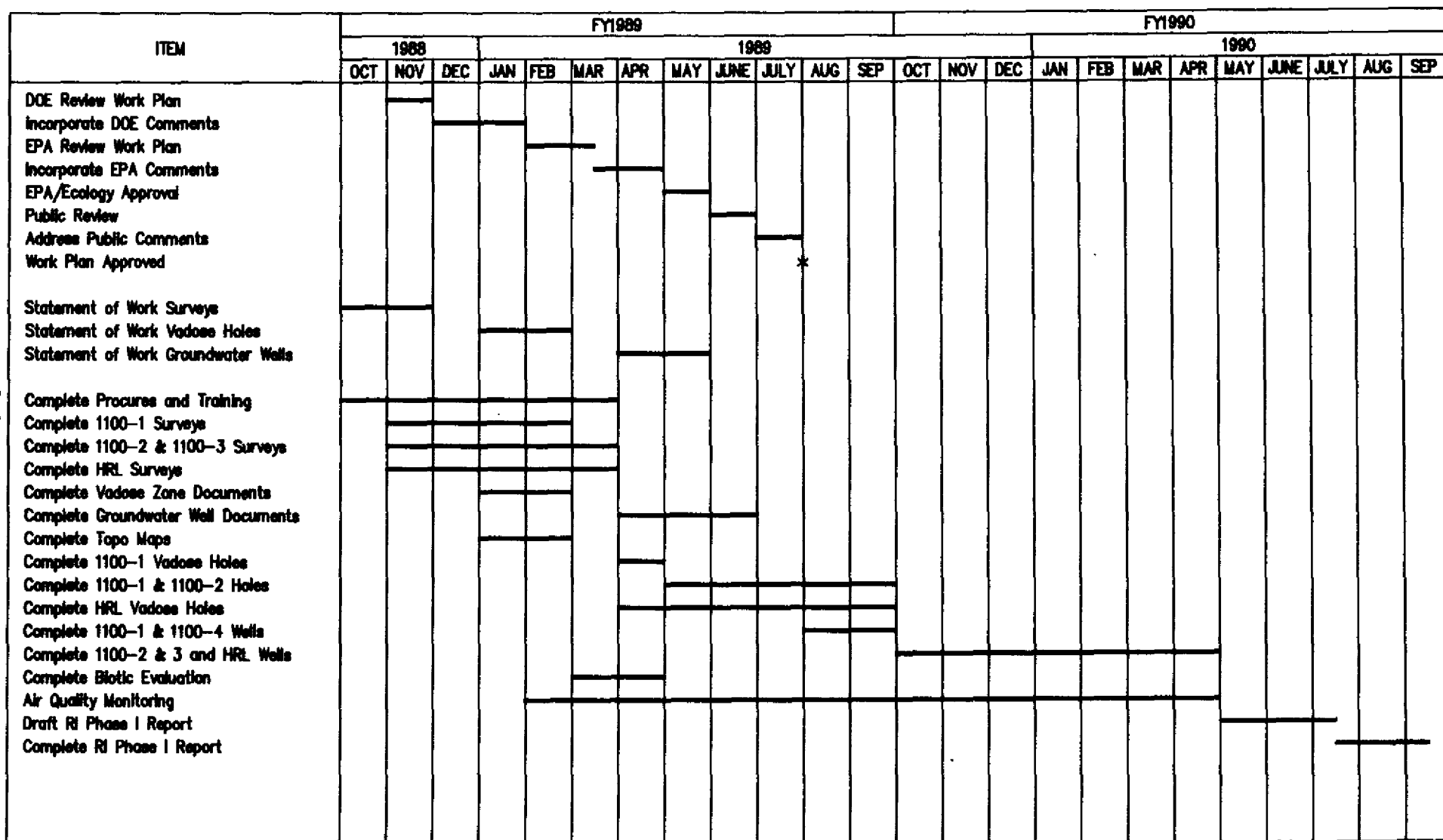
Work plan schedules are shown in Figures 3-11 to 3-16. The RI Phase I schedule is based on the proposed sampling and analysis activities discussed in Section 4.4.

Figure 3-17 contains major milestones, agency approval dates, and agency review cycle periods. In addition, earliest dates that various phases of RI Phase I work can begin are shown. For example, groundwater monitoring wells cannot be constructed until after work plan approval. Surface geophysical surveys and vadose zone characterization can begin earlier than work plan approval as indicated.



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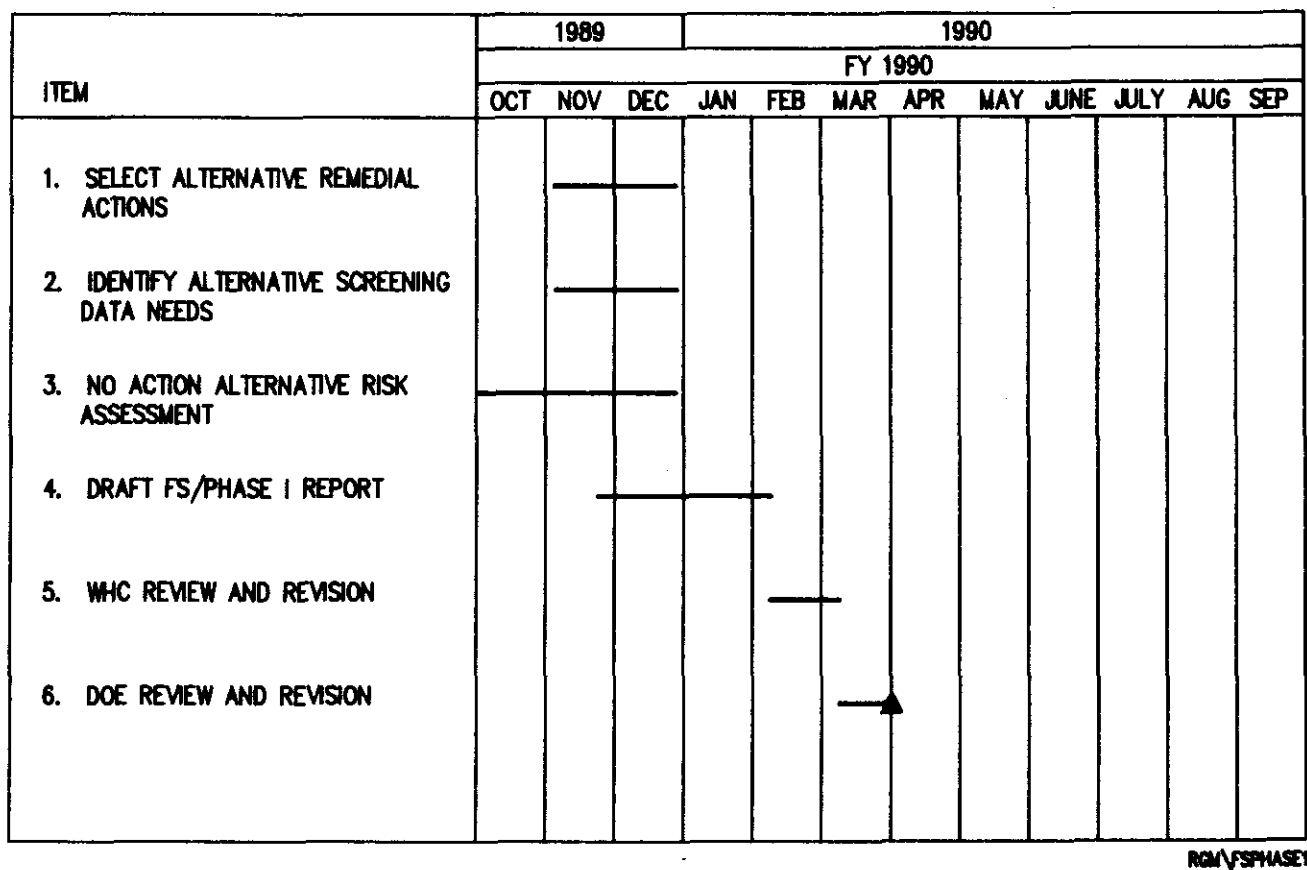
Figure 3-11. Overall Schedule, Hanford Site 1100-EM-1 Operable Unit Remedial Investigation/Feasibility Study.



Note: See Section 5.4 for Details on Controlling Procedures for each Work Phase
 HRL = Horn Rapids Landfill

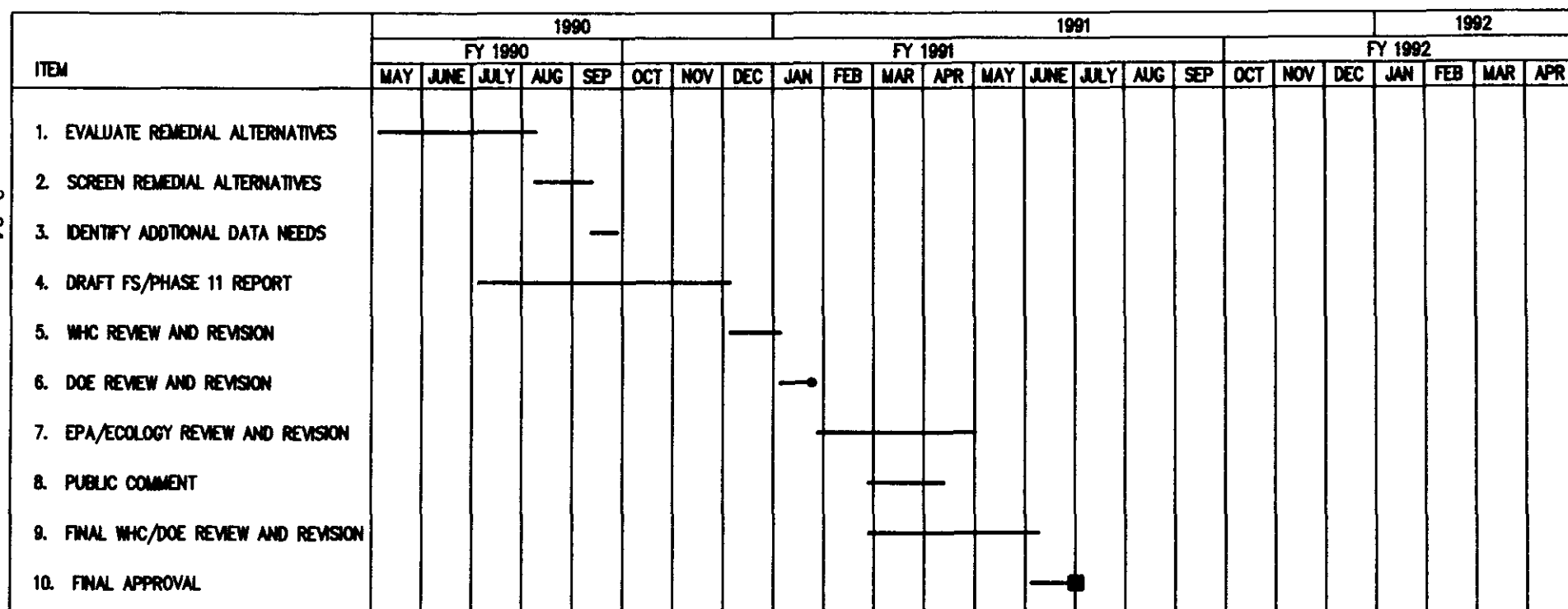
RQA/RI-ACTS

Figure 3-12. Remedial Investigation Phase I.



▲ Issue final RI/Phase I information report.

Figure 3-13. Feasibility Study Phase I.

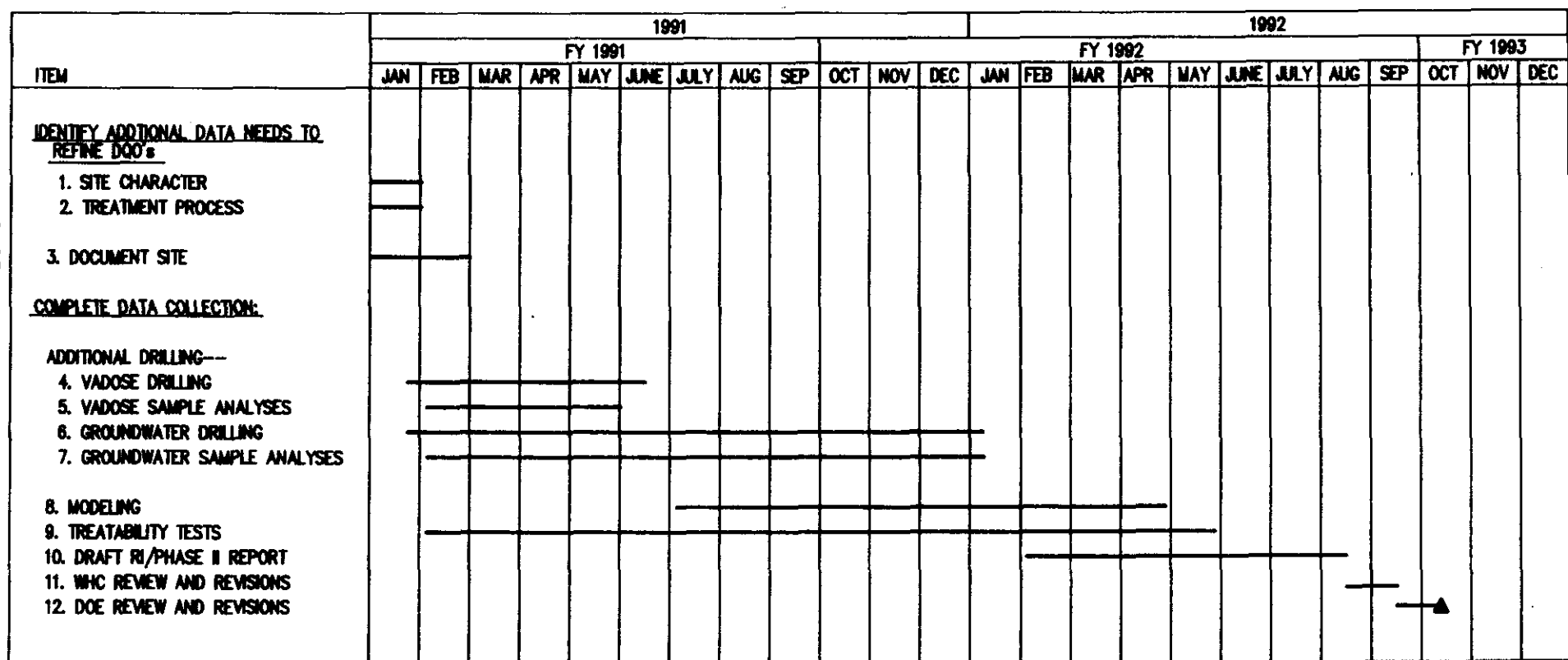


RDM/FS/PHASE2

• Issue draft version for EPA/Ecology approval.

■ Issue final EPA/Ecology approved version of FS/Phase II Report.

Figure 3-14. Feasibility Study Phase II.



R01/PHASE2

▲ Issue final FS/Phase II information report.

Figure 3-15. Remedial Investigation Phase II.

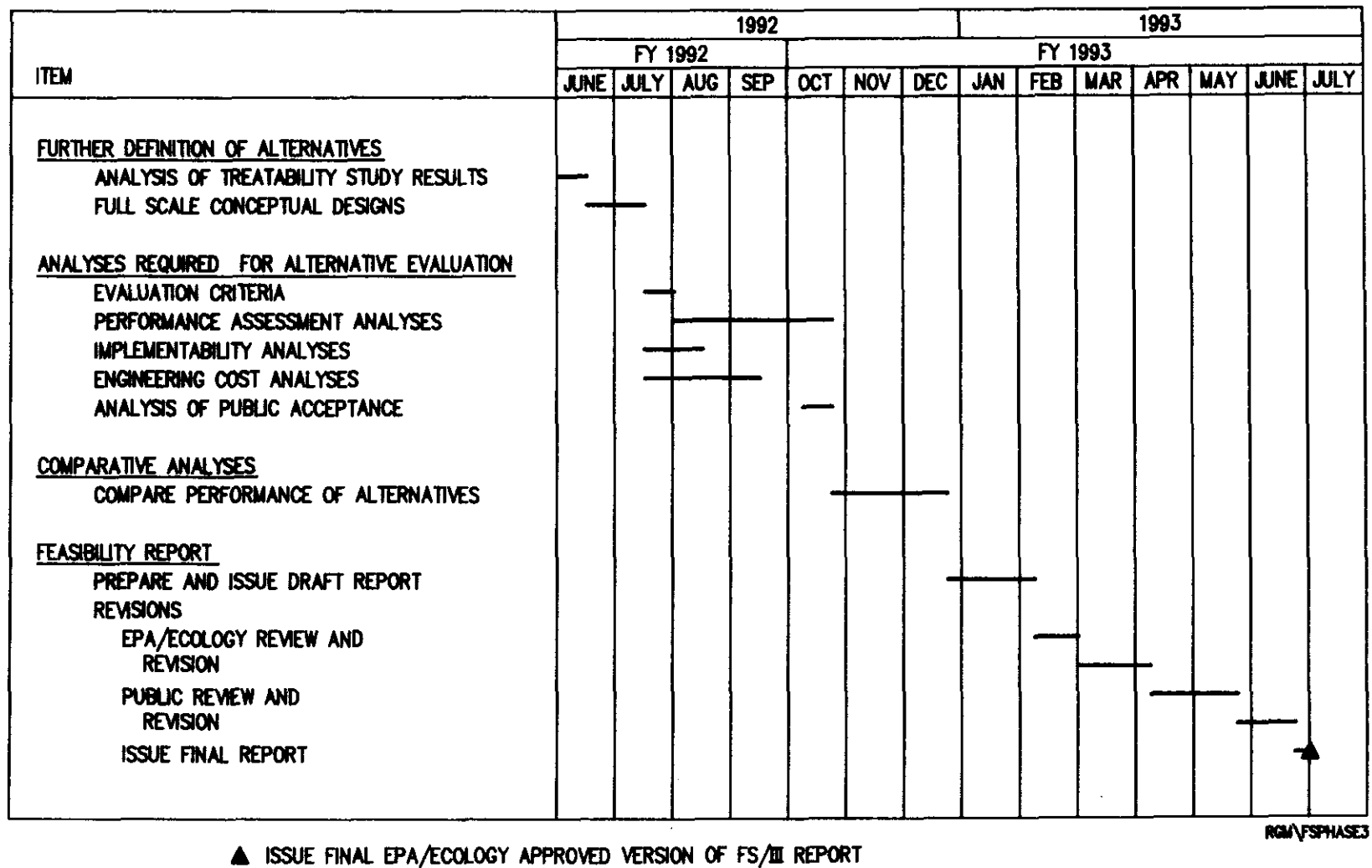
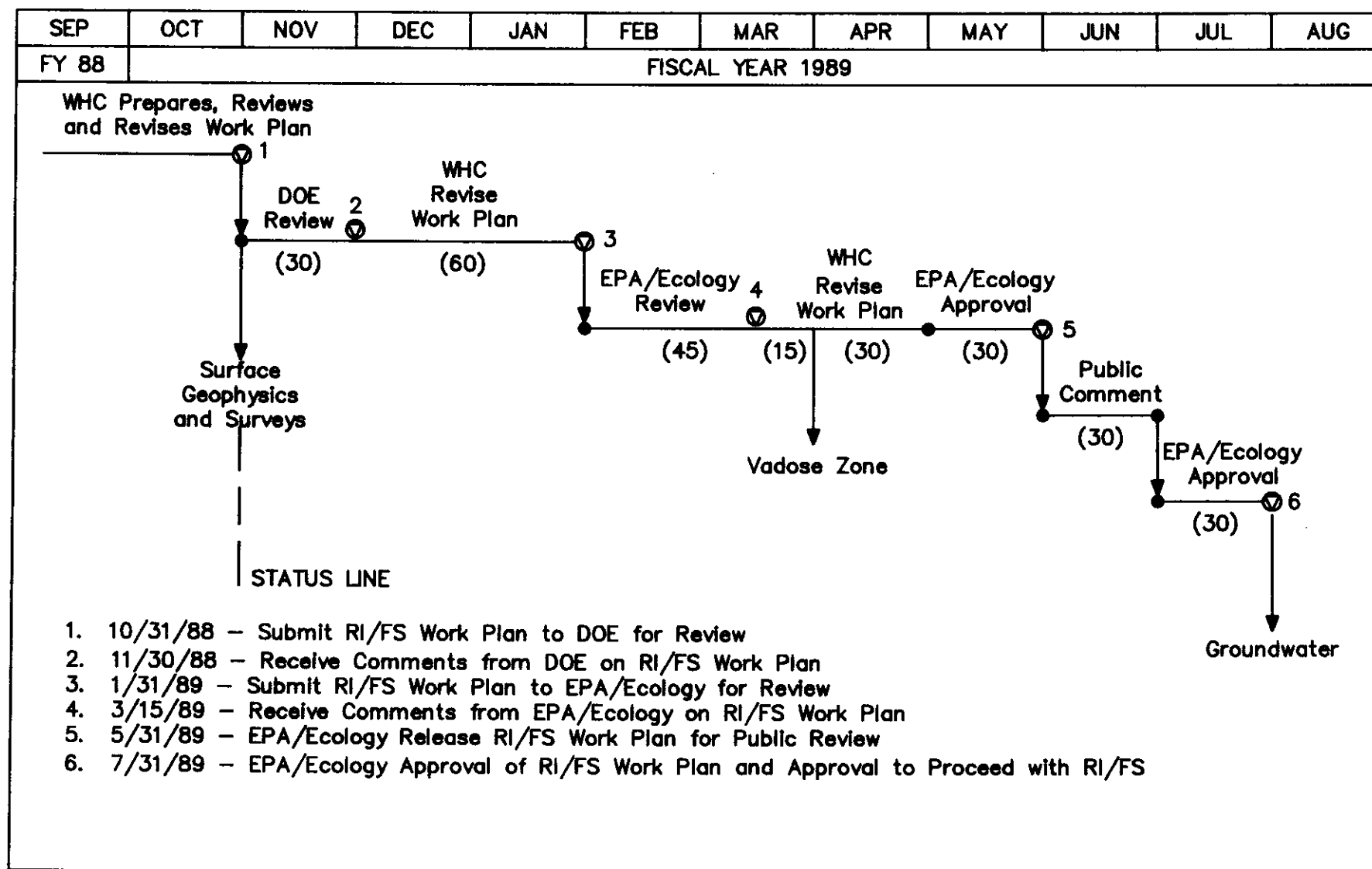


Figure 3-16. Feasibility Study Phase III.



RGM\1100EMWP

Figure 3-17. 1100-EM-1 Operable Unit Remedial Investigation/Feasibility Study Work Plan.

4.0 SAMPLING AND ANALYSIS PLAN

The sampling and analysis plan (SAP) defines the level of effort and specific field activities for the RI. The major elements of the SAP are discussed in four sections. Section 4.1 provides a discussion of site background data and presents a conceptual model that identifies potential contaminant sources, pathways, and receptors. Section 4.2 defines sampling objectives for the RI. Section 4.3 identifies data needs and establishes data quality objectives (DQO). Finally, Section 4.4 presents a detailed discussion of the sampling and analysis program for each media of interest at each site.

4.1 SITE BACKGROUND

The 1100 Area includes equipment storage yards, shipping and receiving facilities, and vehicle maintenance facilities for the DOE's Hanford Site. It occupies approximately 1.2 mi² at the extreme southeast corner of the Hanford Site, along the northwestern edge of the city of Richland. Figure 1-1 shows the general location of the 1100 Area. For the purposes of this work plan, the Horn Rapids landfill is also included within the 1100 Area operable unit (1100-EM-1).

A summary of the site geology, hydrogeology, meteorology, air quality, and environmental setting is given in Appendix A. Available data from analyses of soil and water samples from the vicinity of the 1100 Area are included in Appendix B.

Limited information is available regarding past waste-disposal practices and site conditions in the 1100 Area. Much of the information obtained to date is based on interviews with motor pool and maintenance department workers. This information has led to the identification of six probable waste disposal sites that may require remedial action under CERCLA/SARA. Potential contaminants include spent battery acid, antifreeze, used motor oils and hydraulic oils, solvents, degreasers, paints, paint thinners, and possible radioactive surface contamination.

Approximate locations of each waste site to be investigated are shown on Figure 2-1. Table 2-1 indicates potential contaminants at each site.

The primary environmental concern, with regard to the investigation of the 1100 Area, is the proximity to the city of Richland water supply and other wells. The Duke wells and the north Richland well field (Figure 2-1) supply water to the city of Richland water system. They are within about 0.5 mi of the 1100 Area. The population of Richland (33,578 people, 1980 census) is served by these wells and must be considered as an affected population. Emergency interties also exist to the Kennewick water system and the 300 Area. The Battelle Farms Operations irrigation well, which is completed in the unconfined aquifer, is within a few hundred feet of the 1100 Area east boundary. Other wells that draw water from the unconfined aquifer in the vicinity of the 1100 Area include the Horn Rapids athletic complex, the Lamb-Weston potato processing plant, and various residential irrigation wells in north Richland.

4.1.1 Individual Waste Site Descriptions

The 1100-EM-1 operable unit includes those sites where liquid waste is known (or suspected) to have been disposed to the soil column in the 1100 Area.

Individual waste sites known to exist in the 1100 Area (see Figure 2-1 and Table 2-1) are briefly described below.

4.1.1.1 Battery Acid Pit (1100-1). During the approximate period of 1957 to 1977, waste battery acid was disposed of into an unlined pit (i.e., dry sump or French drain) with sand and gravel in the bottom. The pit is located a few feet from a paved area, near the southwest corner of the 1171 Building, which is a vehicle service, maintenance, and repair building. Figure 4-1 shows the approximate location of the battery acid pit.

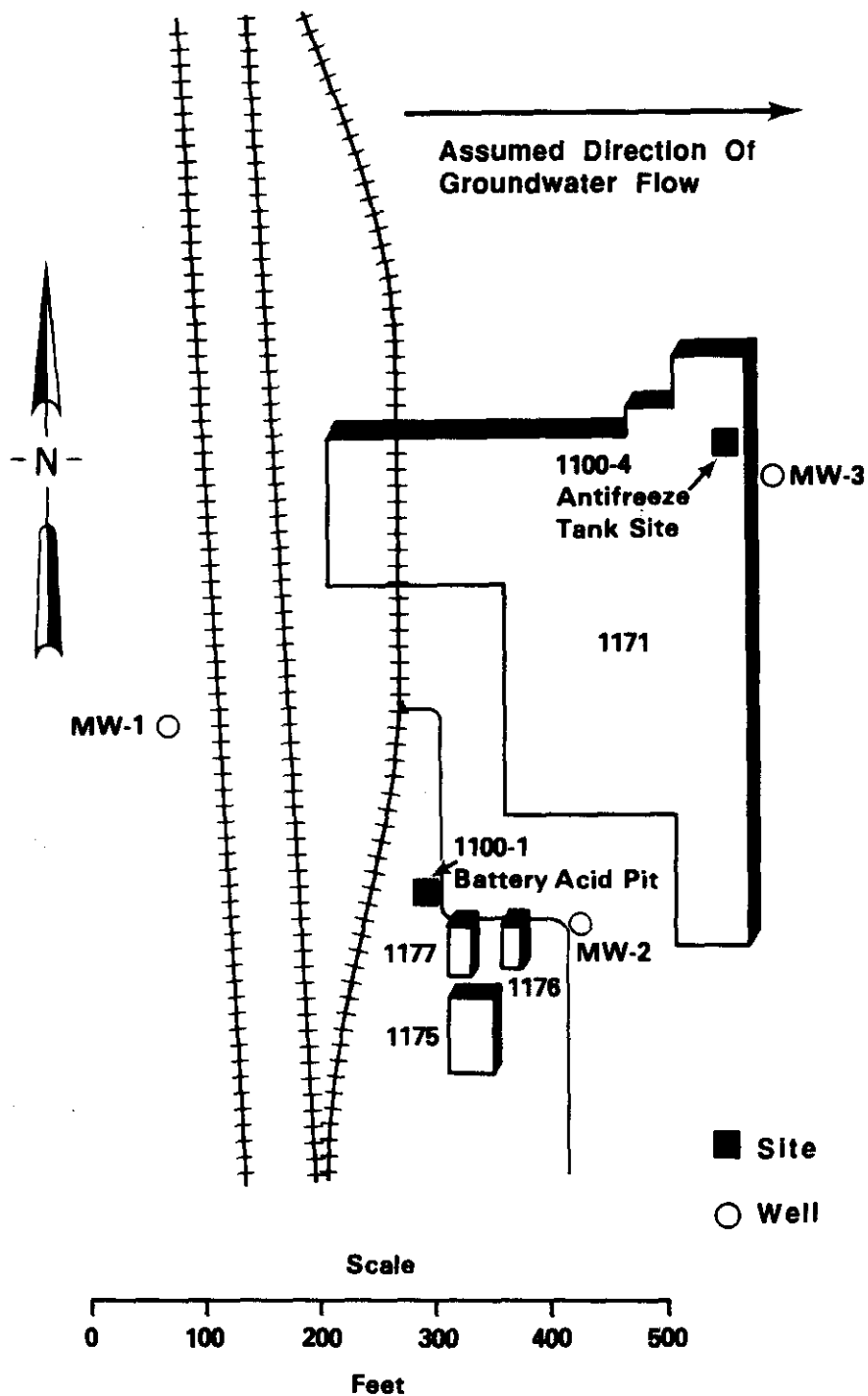
The battery acid pit is located on a very slight slope toward the railroad tracks, which are approximately 50 ft to the west. The exact location and size of the pit is not known, although estimates by motor-pool Workers range from 5 to 12 ft in diameter and 5 to 10 ft deep. Based on a review of vehicle fleet size and estimated battery requirements by Hanford Site personnel, the maximum quantity of battery acid disposed of to the pit over a 20-yr period is estimated to be about 15,000 gal. Other liquid materials, such as waste oil, antifreeze, or solvents, may also have been disposed of in the pit, but no record of such disposal exists.

Depth to water table is about 50 ft from ground surface. No chemical inventory is available. Sulfate, lead, and cadmium compounds are the principal anticipated contaminants. Two surface soil samples obtained in March of 1988 were found to contain elevated levels of lead. The results of these analyses are discussed further in Appendix B.

4.1.1.2 Paint and Solvent Pit (1100-2). Site 1100-2 was used for disposal of solvents, paints, and thinner, as well as construction waste, over the period from 1954 to 1985. The general location of the pit is shown in Figures 2-1 and 4-2. According to interviews with 1100 Area personnel, the construction waste is reported to be broken concrete, asphalt, and lumber from construction and maintenance activities on the Hanford Site.

The site is presently covered by approximately 5 ft of spoil material mixed with a small quantity of waste asphalt from highway construction conducted in the early 1980s. The site is approximately 250 ft long and 100 ft wide. The depth to the water table is about 50 ft from ground surface. There is no visible evidence of paint, solvent, or discolored soil on the surface in the vicinity of this site. The exact locations of paint and solvent disposal at this site are unknown.

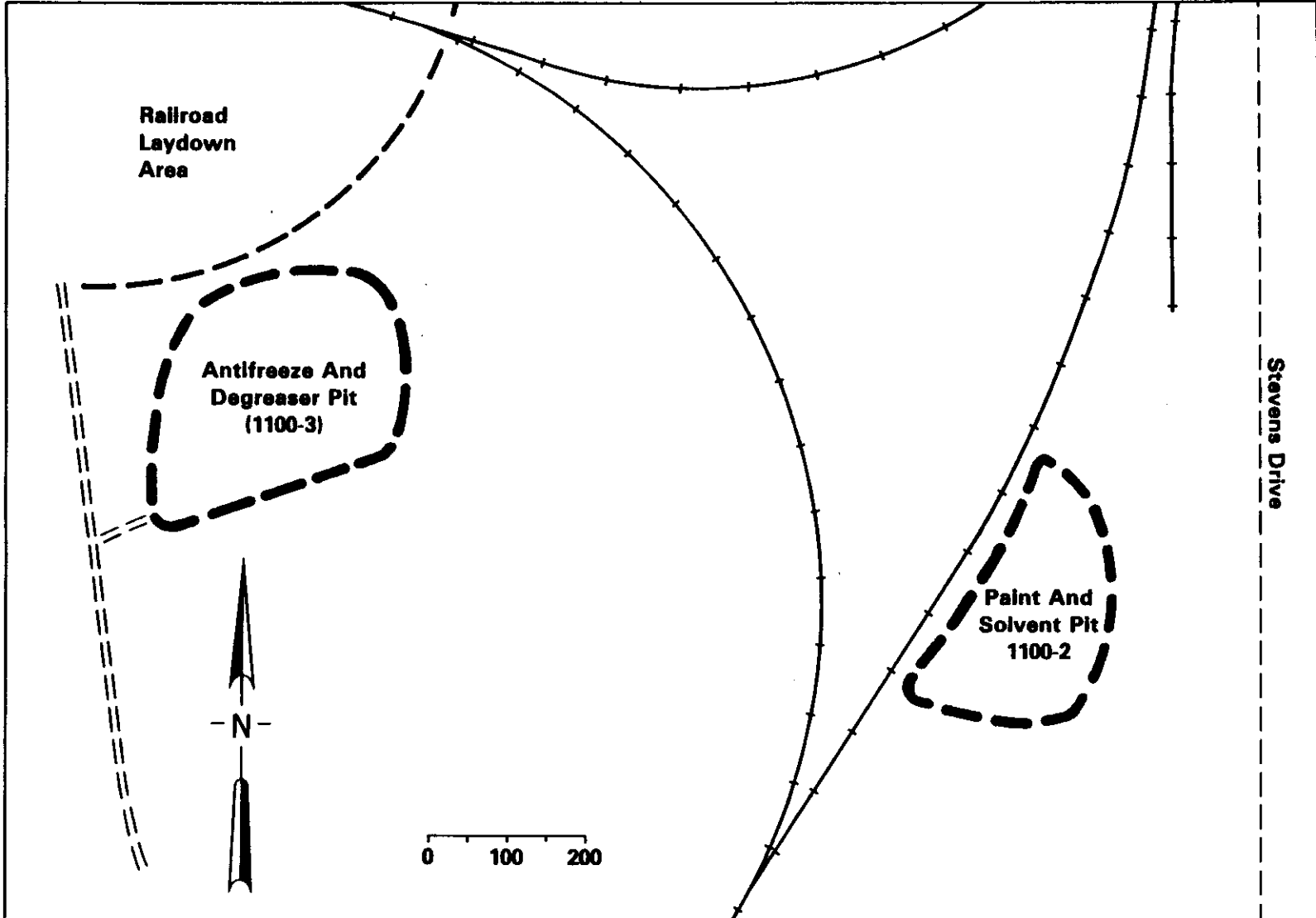
No chemical inventory is available, but analyses of two surface soil samples obtained in March 1988 reveal no evidence of contamination. The maximum volume of paint thinner and other solvents disposed of in the pit is estimated to be on the order of 100 gal/yr. Over the 30-yr operating history of the pit, the total estimated volume is approximately 3,000 gal.



Note: Locations shown are approximate

28008.063.2

Figure 4-1. Location of the Battery Acid Pit and Antifreeze Tank Site.



28808.063.3

Figure 4-2. Waste Site Locations.

4.1.1.3 Antifreeze and Degreaser Pit (1100-3). The antifreeze and degreaser pit is a shallow excavation about 250 ft in diameter (Figure 4-2). The depth to the water table is estimated to be approximately 50 ft below land surface. It is reported to have been an excavation for sand and gravel borrow material, with the bottom of the original pit at roughly the present observed depth. Approximately 30 yd³ of used roofing gravel and 1 yd³ of concrete rubble lie in piles dumped on the relatively level bottom of the borrow pit. The quantity of antifreeze and degreasers, as well as specific disposal locations within the pit, are unknown. No chemical inventory is available, but analysis of two surface soil samples taken in March 1988 revealed no evidence of contamination.

4.1.1.4 Antifreeze Tank Site (1100-4). This site is the location of a 5,000-gal underground steel tank used for disposal of waste antifreeze in the 1171 Building. In 1986, the tank was emptied, cleaned, and subsequently removed because it was suspected of leaking. No information is available on the amount of antifreeze that may have leaked. During excavation of the tank, three soil samples were collected from soils surrounding the tank. Analysis of surface soil samples did not detect antifreeze (ethylene glycol) in any of the samples.

4.1.1.5 Radiation Contamination Site (1100-5). On August 24, 1962, radioactive contamination was discovered on an incoming 16-ton cask containing irradiated metal specimens from a facility at the Idaho National Engineering Laboratory, and on the truck trailer carrying the cask when it arrived at the 1100 Area. After the truck unloaded other cargo at the 1166 Building receiving area, it was parked "in the parking lot northwest of the 1171 Building."

The radiation incident investigation report indicates that an area approximately 1 ft in diameter on the bed of the trailer was contaminated. Because of concern over leakage from the cask, radiological checks were conducted at several locations including the 1166 Building loading dock, the Pacific Intermountain Express terminal in Pasco, Washington, and a parking lot in Baker, Oregon, where the truck was parked for approximately 8 h. No contamination was detected. The U.S. Atomic Energy Commission officials in Idaho surveyed a location in Twin Falls, Idaho, and found some contamination, which was removed and buried. Based on available information, significant contamination of the parking lot seems highly unlikely. A logical assumption is that Hanford Site radiation monitors carefully checked the ground beneath the trailer; however, the investigation report does not explicitly make such a statement.

4.1.1.6 Horn Rapids Landfill. The Horn Rapids landfill (Figures 2-1 and 4-3) is an inactive disposal site that was used primarily for office and construction waste. This is not to be confused with the city of Richland municipal-waste disposal site. Discussions with Hanford Site personnel involved in the operation of the landfill indicate that other wastes are likely present, including possibly as many as 200 drums of carbon tetrachloride. Mention is made of standing water and "springs," which indicates that the bottom of the landfill may be just above or in contact with the groundwater. The depth to the water table is estimated to be approximately 30 ft. At present, the Horn Rapids landfill is a designated curlew nesting area, and access is restricted.

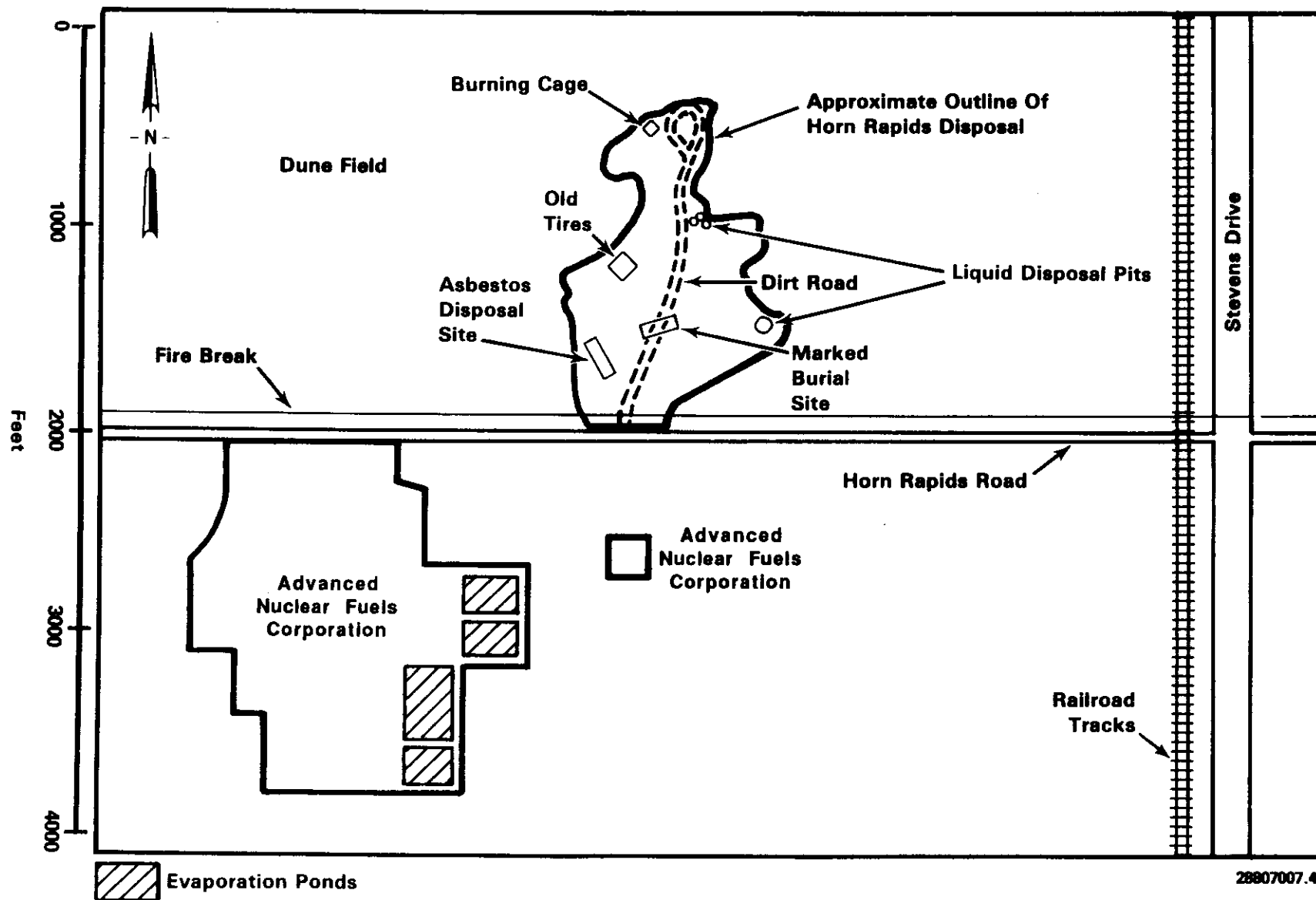


Figure 4-3. Horn Rapids Landfill.

No detailed waste inventory is available. One cell of the landfill is marked by signs indicating that asbestos is buried there. Nearby there are two locations, several yards apart, that have signs with the legend "Burial Site". These apparently mark an earlier trench, but what was buried there is unknown. Used tires occupy an open trench at the northern end of a landfill cell. Another area is surrounded by a low berm and occupied by a dark gray-brown mud-like substance that exhibits mud-cracks. This site appears to have been used for disposal of unknown liquid materials, possibly including sewage sludge and/or fly ash.

4.1.1.7 "Discolored-Soil" Site. In the course of the site inspection for the 1100-EM-1 operable unit waste sites, two additional potential waste sites were found. The first was an area of what appeared to be asphalt or oily material on the face of the sand dune north of the 1171 Building. The second was a patch of oily, discolored soil in an elongated natural depression near an abandoned irrigation canal and adjacent to the railroad tracks northwest of the 1171 Building. Grab samples of surface soils were taken from each of these sites. Subsequent discussions with 1100 Area personnel revealed that the first site was the remnant of an asphalt emulsion applied in an attempt to stabilize the sand dune in the early 1960s. Results of the analysis for the soil sample are generally consistent with asphalt, and this site will not be considered further. However, the sample from the second site was found to contain measurable concentrations of two phthalates, nine unknown acid-base neutrals, and elevated total organic carbon (TOC). Hence, this site has been designated as the "discolored-soil" site and will be investigated further. This site appears to be the location of at least one, and possibly several, incidents where one or more drums of liquid material were poured onto the ground.

4.1.2 Interactions with Other Operable Units

Two additional operable units have been identified in the 1100 Area. These are designated 1100-EM-2 and 1100-EM-3. Geographic boundaries are not precisely defined, and there is overlap between 1100-EM-1 and 1100-EM-2. The primary criteria for grouping into operable units are waste characteristics and the nature of the facility. All inactive sites tentatively identified for remedial action under CERCLA are grouped under 1100-EM-1.

The 1100-EM-2 operable unit consists of active waste sites or waste staging areas in the vicinity of the 1171 Building. These units are in the same general vicinity as the battery acid pit (1100-1), the antifreeze tank (1100-4), and the radioactive contamination spill site (1100-5). At the present time, these sites are anticipated to be addressed under the RCRA permit process.

The 1100-EM-3 operable unit consists of waste sites in the 1100 Area east of Stevens Drive. Although geographically distinct from 1100-EM-1 and 1100-EM-2, these sites may also contain similar wastes. Many of these sites are located between the 1100-EM-1 operable unit and the north Richland well field. As with 1100-EM-2, they are considered to be active and will be addressed under RCRA.

Although both 1100-EM-2 and 1100-EM-3 contain sites not specifically addressed in this RI/FS, they represent potential sources of similar types of contamination. This must be accounted for in conducting the investigation and in planning RA for groundwater contamination associated with the 1100-EM-1 operable unit.

In addition to DOE waste sites identified in the three operable units, other waste sites or potential sources of contamination exist in the vicinity of the 1100 Area. These include the nuclear fuels processing facility operated by Advanced Nuclear Fuels, the Lamb-Weston potato processing plant, the city of Richland landfill, and several small businesses, including at least one gas station and one automobile machine shop/repair facility.

4.1.3 Summary of Existing Operable Unit Data

Data pertaining to possible contamination of soil and/or groundwater resulting from waste disposal operations in 1100-EM-1 are limited. Existing data consist of the following: (1) two analyses by the State of Washington of well-head water from the north Richland and Duke well fields operated by the city of Richland, (2) two analyses by the Hanford Environmental Health Foundation (HEHF) of well-head water from the north Richland well field, (3) 11 preliminary analyses of water samples from wells in the 1100 and 3000 Areas and vicinity taken during 1986, (4) analyses of water samples from seven wells in the vicinity of the 1100 Area conducted in August 1988, (5) analyses of water samples from five monitoring wells installed along the eastern margin of the 1100 Area in November 1988, and (6) eight surface soil samples from the 1100 Area. The groundwater data do not serve to establish whether or not the 1100-EM-1 operable unit is a source of contamination. Given below is a brief summary of existing data. The analytical data obtained from these studies can be found in Appendix B.

The analyses of well water from the city of Richland well fields indicated that trihalomethanes (bromoform, bromodichloromethane, and chloroform) were the only regulated compounds present in the groundwater and were only detected in samples from the north Richland well field. The concentrations of trihalomethanes detected were considerably less than the allowable values under the preliminary ARARs. Trihalomethanes are commonly associated with chlorinated water and are not believed to have come from the 1100 Area.

Analyses of samples from wells in the 1100 and 3000 Areas and vicinity have also indicated the presence of regulated compounds in the groundwater. The data obtained from the 1986 sampling (Appendix B) indicates the presence of methylene chloride, bis(2-ethylhexyl) phthalate, and several metals (barium, cadmium, and lead). Well S41-13C (3000-D-1), which is located in the vicinity of the 1100-2 and 1100-3 disposal pits, showed a concentration of 20 parts per billion (p/b) of methylene chloride. However, concerns regarding details of well construction, the age of the wells, and the procedures used for collection and analysis of the samples suggest the data may not be reliable. Analyses of samples taken during August 1988 showed that bromodichloromethane, chloroform, 1,1,1-trichloroethane, and trichloroethene are present in the groundwater in the vicinity of the 1100 Area. The concentrations of these compounds were all at least 20 times

less than concentration levels specified in preliminary ARARs. However, the wells are not optimally located to detect potential dispersal plumes associated with the sites. Hence, the degree and extent of contamination cannot be adequately judged.

In October 1988, five monitoring wells were installed in the area between the 1100-EM-1 waste sites and the north Richland and Duke wells. The purpose of these wells is to detect any contaminants that may be migrating from the 1100 Area waste sites toward the water supply wells. Chemical analyses of water samples obtained from these wells in early November were conducted by U.S. Testing and Pacific Northwest Laboratory (PNL). Results indicated that all constituents are below drinking water standards. Methylene chloride was detected in initial samples from three of the wells at concentration levels as high as 78 p/b. However, subsequent sampling and analyses by PNL have failed to detect methylene chloride (detection limit 3 p/b), indicating that this is probably the result of contamination during the sampling process. Results of these analyses are included in Appendix B.

Eight preliminary surface soil samples were taken in March 1988 from several sites in the 1100 Area and vicinity. Of the samples taken from the battery acid pit (1100-1), the paint and solvent disposal site (1100-2), and the antifreeze and degreaser pit (1100-3), only those from the 1100-1 site had elevated concentrations of regulated compounds. The samples from 1100-1 contained elevated levels of lead and possibly slightly elevated levels of mercury, chromium, and arsenic. One sample from 1100-1 also contained a measurable concentration of the polychlorinated biphenyl (PCB) arochlor 1254.

The sample from the "discolored-soil" site west of the tracks contains measurable concentrations of two phthalate, nine acid-base neutrals, and elevated TOC.

4.1.4 Conceptual Model

This section describes a conceptual model to support qualitative risk assessment and RI/FS planning for the 1100-EM-1 operable unit. Guidance from EPA's Data Quality Objectives for Remedial Response Activities (EPA 1987a) requires the conceptual model to describe the site and its environs and to present a hypothesis regarding the dynamics of contaminant migration at the site.

The conceptual model incorporates available data on site conditions, waste sources, pathways, and receptors and provides a basis for evaluation of potential risks to human health, safety, and the environment. The conceptual model includes all known or suspected sources of contamination, types of contaminants, affected media, and known or potential routes of migration and all known or potential human and environmental receptors. Data for the 1100 Area are limited and, in many cases, assumptions must be made, or conditions must be extrapolated from other locations. However, the present conceptual model contains sufficient detail to provide a basis for planning initial field investigation efforts. The conceptual model will be revised as necessary to incorporate data obtained from field investigations.

The current understanding of the 1100-EM-1 operable unit conceptual model is depicted in Figure 4-4. This generic conceptual model identifies potential waste sources, release mechanisms, pathways, and receptors, as well as other sources of recharge or discharge from the unconfined aquifer that may affect contaminant migration.

All of the individual sites in the 1100-EM-1 operable unit exhibit interior drainage. No standing water has been observed at any of the sites, and the general character of surface sediments is such that the presence of standing water at the ground surface for any significant time period is unlikely. Hence, drainage to surface water is not considered a credible pathway for contaminant migration.

Because of existing soil cover, volatilization of wastes is not considered a credible release mechanism.

Air entrainment and transport of contaminated fugitive dust is considered unlikely until the sites are disturbed.

Figures 4-5 and 4-6 present generalized east-west geologic cross-sections in the 1100 Area and vicinity. The cross-section shown in Figure 4-5 passes through the battery acid pit (1100-1) and the north Richland well field. The cross-section shown in Figure 4-6 passes through the Horn Rapids landfill and illustrates the potential for direct or nearly direct contact between groundwater and waste at the Horn Rapids landfill. These cross sections reflect the current understanding of geologic and hydrologic characteristics based on limited and extrapolated data. Figures 4-4, 4-5, and 4-6 are used to support the conceptual model description that follows.

4.1.4.1 Waste Sources. Known and suspected waste types are given for each site in Table 2-1. With the exception of 1100-4 and the Horn Rapids landfill, all liquid waste sites are the result of waste discharge directly to the soil. The 1100-4 tank was an antifreeze-holding tank suspected of leaking. The tank has since been removed. Hence, contaminated soil is the primary potential source of contaminants. The Horn Rapids landfill may contain buried drums and other forms of buried waste. Buried drums or other types of buried waste containers may also exist at 1100-2 and 1100-3. Although there are no records to confirm the presence of buried waste containers, the possibility cannot be discounted at this time.

4.1.4.2 Pathways. The primary contaminant migration pathway is assumed to be infiltration and percolation through the soil column into the unconfined aquifer. In the case of the Horn Rapids landfill, the path from the waste may be very short or waste may be in direct contact with groundwater (see Figure 4-6).

Contaminants from waste sites in 1100-EM-1 are assumed to have traveled through eolian sands and glaciofluvial sediments to reach the unconfined aquifer at a depth of approximately 50 ft below the surface. At the Horn Rapids landfill, the waste may be in direct contact or very close to the water table. In this case, contaminants may also be leached from the waste.

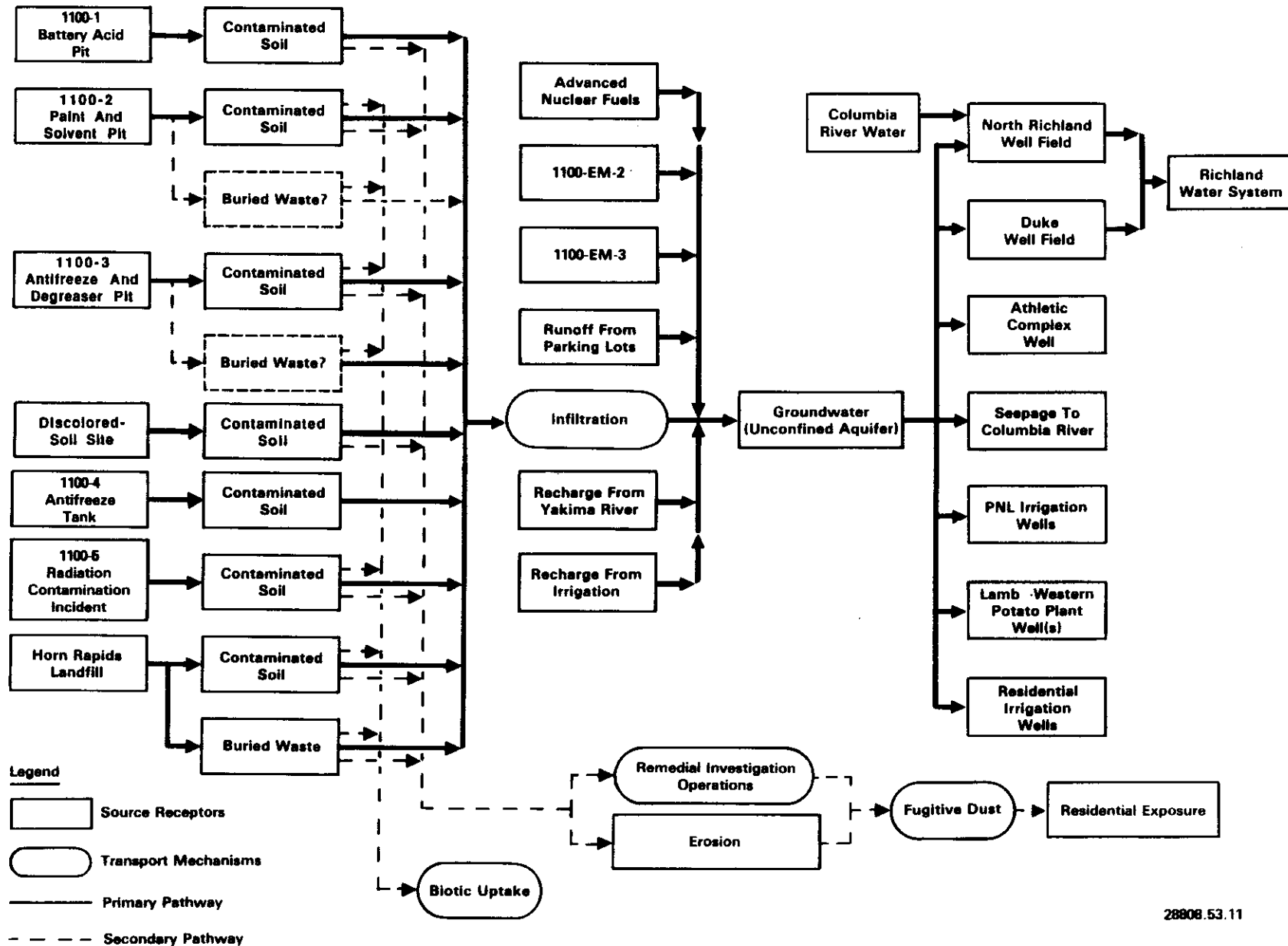
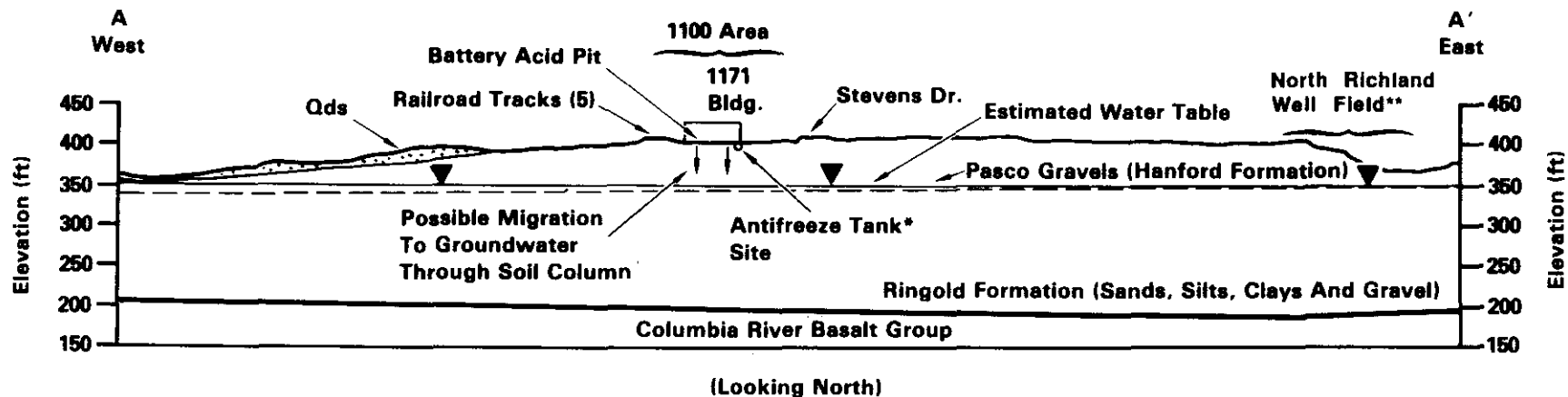


Figure 4-4. 1100-EM-1 Operable Unit Conceptual Model.



Qds = Dune Sands

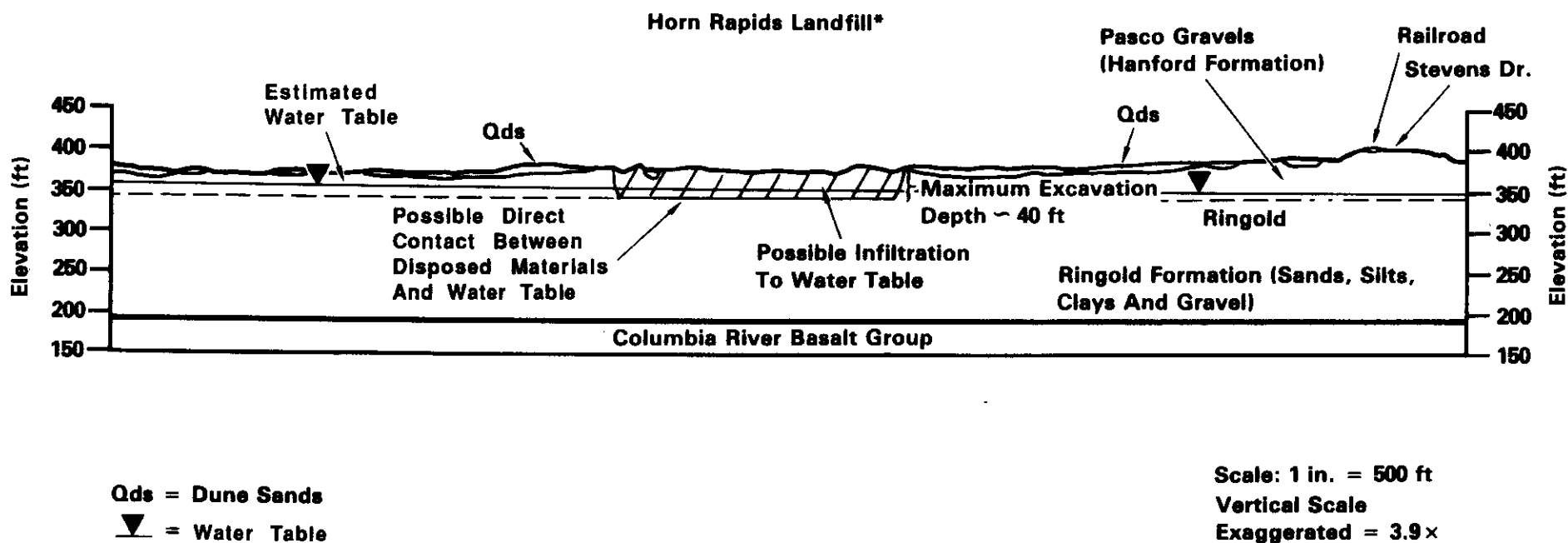
Horizontal Scale: 1 in. = 500 ft
Vertical Scale Exaggerated (3.9x)

*Projected ~ 375 ft To Line Of Section.

** Hypothetical Location -
Exact Location Unknown,
Water Table in Vicinity
Of North Richland Well
Field Is Variable In
Time And Space

28808.53.7

Figure 4-5. Battery Acid Pit and Antifreeze Tank Site Cross-Section.



* Specific Locations Within The Landfill Are Approximate And Are Projected To Line Of Section

28908.53.8

Figure 4-6. Horn Rapids Landfill Site Cross-Section.

Groundwater beneath the 1100 Area occurs in the unconfined aquifer of the Pasco Gravels and in sands and gravels of the Ringold Formation. The lower blue clay member of the Ringold Formation is considered an aquitard. Groundwater flow is assumed to be generally from west to east. Recharge occurs from the Yakima River, agriculture irrigation, the Lamb-Weston potato processing plant waste treatment system, and the north Richland well field. Little or no recharge is anticipated from natural precipitation. A confined or semiconfined aquifer may occur in sands and gravels of the Ringold Formation underneath or within the lower blue clay member of the Ringold Formation.

The groundwater flow conditions beneath the site are assumed to vary temporally and spatially as a result of recharge from irrigation, variations in pumping rates at the various wells, and differences in hydraulic conductivity in the area. The 1100 Area is not presently included within the Hanford Groundwater Monitoring Network, so detailed water-table maps and water-chemistry data are not available. However, a total of five groundwater monitoring wells have recently been drilled in the 1100 Area as part of the Hanford Groundwater Monitoring Program.

Travel times for contamination to reach the north Richland well field from potential sources in the 1100 Area are difficult to estimate at this time because of the lack of available data concerning the volume and frequency of waste disposal, as well as details of the hydrogeologic system. Ignoring travel time in the vadose zone, adsorbing qualities of the soil, chemical reactions of the waste with the soil, and other contaminant transport factors such as dispersion, estimates of minimum travel time could be calculated by estimating groundwater travel time in the saturated soil zone. However, estimates of groundwater travel time rely heavily on hydraulic conductivity that may vary as much as three orders of magnitude in Ringold Formation and glaciofluvial sediments. In the 1100 Area and vicinity the water table is generally within the lower portion of the glaciofluvial sediments, but at some locations it may lie within the Ringold Formation (Figures 4-5 and 4-6).

For example, using a hydraulic conductivity of 20 ft/d (a low value for the Ringold Formation), a hydraulic gradient of 10 ft/mi (or 0.002), and an effective porosity of 15%, groundwater travel time for the 3,150-ft distance to the north Richland well field is 34 yr. Changing the hydraulic conductivity to 20,000 ft/d (a high value for the Pasco gravels), the travel time would be 12.5 d. These estimates represent bounding values. As more information becomes available during the RI, better estimates of groundwater flow will be possible and, in turn, these estimates will help determine contaminant travel time.

Ultimately, any contaminated groundwater from the 1100 Area will probably reach the Columbia River. As a result the Columbia River could be considered another receptor. However, any contamination reaching the Columbia River through the groundwater system is likely to be tremendously diluted by the very large volume of water in the Columbia River stream flow. This large dilution creates a problem in the detection and monitoring of low levels of contamination from potential 1100 Area sources. As a result, the emphasis during the early phases of the RI will be to characterize the soil and groundwater beneath and downgradient of the 1100 Area to determine

whether contamination has reached the groundwater system. Should contamination be discovered in the groundwater, plans for monitoring the Columbia River will be developed for later phases of the RI/FS.

A possible secondary pathway is fugitive dust resulting from site activities or construction. Deposition of fugitive dust in the Richland well field ponds or in other accessible areas represents a minor concern, but must be considered to assess the cumulative impact of 1100-EM-1.

Another possible secondary pathway by which contaminants may reach the environment is uptake by biota. At 1100-1, 1100-4, and 1100-5, there is no vegetation. Each of these sites is located within an area where vegetation is precluded by the facility.

Sites 1100-2, 1100-3, and the Horn Rapids landfill are characterized primarily by sagebrush and cheatgrass and a population of rodents and birds. The probability of biotic uptake at these sites is very low due to the sparse density and shallow rooting depths of the plants involved.

4.1.4.3 Receptors. The most significant potential receptor for contaminants that reach the unconfined aquifer is the water supply system for the city of Richland. This system supplies water for a population of approximately 33,600 people (1980 census). For the purposes of this conceptual model, the wells nearest the 1100 Area will be considered receptors. This includes the north Richland well field and the Duke wells. Other possible receptors include the PNL irrigation wells, the Horn Rapids athletic complex well, well(s) at the Lamb-Weston potato processing plant, and various residential irrigation wells. In general, the contamination problem in the 1100 Area can be defined in terms of contaminant levels in water withdrawn at the various wells.

4.2 SAMPLING OBJECTIVES

The SAP is a major component of the overall RI/FS work plan and provides specific direction for conduct of the RI. The RI/FS will be conducted in phases, as indicated in Figure 1-2. The RI and the FS will proceed in parallel, with the RI providing data to support FS activities. Because there is no definitive evidence of contamination in the 1100 Area, the initial phase of the RI/FS will be to determine if contamination is present to the extent that remedial action is warranted. If no evidence of contamination is found, data from the Phase 1 RI will be incorporated in a decision document and the decision to terminate the RI/FS will be formalized in the ROD, after review and comment by EPA, Ecology, and the public. If contamination is found, the RI/FS will be implemented to identify and evaluate appropriate remedial alternatives (which may include no action).

It is anticipated that both the conceptual model and the SAP will be revised as the work proceeds to accommodate an improved understanding of site conditions and specific data requirements associated with evaluation of remedial alternatives. Initially, the questions to be answered are whether or not contamination exists at the site, what contaminants are present, and

whether or not contaminant levels exceed regulatory limits or action levels. Other data will be collected to improve the overall understanding of site conditions.

Because relatively little site-specific data are available for the 1100 Area, Phase 1 of the RI will be performed in two phases, designated as 1A and 1B. This approach is being taken to maximize the benefit associated with relatively expensive investigation activities such as drilling and groundwater sampling by first finding likely places for sampling with less sensitive, inexpensive survey techniques.

Phase 1A activities will consist of survey techniques conducted to identify zones of potential contamination (e.g., "hot spots") and to identify probable contaminants. Techniques to be used under Phase 1A include evaluation of aerial photography, geologic mapping, soil-gas surveys, and geophysical surveys.

Phase 1B activities will consist of more detailed investigation and sampling, such as auger holes, soil borings, and monitoring wells to investigate anomalies identified in Phase 1A. Specific locations for sampling activities under Phase 1B will be determined on the basis of information obtained from Phase 1A.

Phases 1A and 1B are based on location and sampling of zones of contaminated soils. In the event that buried drums or other waste containers are detected by Phase 1A survey activities, auger holes and soil borings planned under Phase 1B will be relocated as necessary to avoid penetrating waste containers. The SAP will be modified as appropriate to include provisions for exhumation and/or sampling of the contents of buried waste containers. The methods to be used will be dependent on the circumstances.

Specific objectives of Phases 1A and 1B of the RI are as follows.

- Determine nature and extent of contamination.
 - Waste constituents/types
 - Waste characteristics
 - Contaminant concentration (including spatial variability)
 - Potential contaminant inputs from nearby industrial processes or other operable units
- Obtain data necessary to protect worker health and safety during remedial investigation activities.
- Obtain data to improve the preliminary conceptual model.
- Provide data to conduct a preliminary baseline risk assessment.

Subsequent phases of the RI will have the following objectives.

- Determine characteristics of primary contaminant transport pathways.
 - Vadose zone characteristics
 - Aquifer and aquitard characteristics
 - Identify and develop quantitative estimates of aquifer perturbations
 - Biotic characteristics
 - Meteorological/dispersion parameters
- Determine contaminant transport characteristics for each credible site pathway.
 - Nature and rate of contaminant release from waste source
 - Waste degradation characteristics
 - Contaminant mixing/dispersion
 - Possible synergistic/antagonistic effects
 - Contaminant sorption/retention
- Obtain sufficient data to assess the threat to public health and to conduct risk assessments.
- Obtain sufficient data to identify candidate remedial action technologies and to conduct a preliminary screening.
- Obtain sufficient data to determine what technically feasible and cost-effective measures can be applied to achieve regulatory compliance.
- Obtain sufficient data to estimate the resources, costs, and time periods required to apply the recommended remedial measures.

The phased sampling approach encourages timely identification of key data needs and ensures that data collection activities provide information relevant to the selection of a remedial action.

Each of the sites in the 1100 Area is unique and will require modifications based on individual conditions. For example, sites 1100-1 and 1100-4 are of limited areal extent, and their locations are well known. Hence, sampling activities such as borings or pits can be started with minimal Phase 1A activities. Sites 1100-2, 1100-3, and the Horn Rapids landfill are much larger and will require areal screening by means of Phase 1A survey techniques to identify likely areas for Phase 1B borings. The final number

and size of the areas to be investigated in detail, as well as the final number of pits, borings, and monitoring wells will depend to a large degree on the results of the Phase 1A surveys.

4.3 DATA NEEDS AND DATA QUALITY OBJECTIVES

To define data needs for planning the RI, it is necessary to identify data users and determine what uses will be made of the data. Existing data can then be evaluated in terms of adequacy with regard to their proposed uses in the RI/FS. In this way, data gaps that must be satisfied can be identified, and the RI can be focused to obtain the needed data in a cost-effective manner. Most data uses are associated with decisions inherent to the RI/FS process. Major decisions associated with the RI/FS are shown in Table 4-1. The goal of this section is to identify the data needs that must be satisfied to make the decisions indicated in Table 4-1 and to present preliminary DQOs that will provide a basis for planning the initial phase of the data collection program.

Table 4-1. Decisions Involved in the Remedial Investigation and Feasibility Study Process.

<p>For Each Site:</p> <ul style="list-style-type: none"> • Does contamination exist? • What contaminants are present?
<p>For Each Contaminant at Each Site:</p> <ul style="list-style-type: none"> • What are the likely pathways or mechanisms for contaminant transport or migration?
<p>For Each Pathway and Each Contaminant at Each Site:</p> <ul style="list-style-type: none"> • Do present contaminant concentrations exceed allowable levels? <ul style="list-style-type: none"> - Is immediate action necessary? - Is remedial action required? • What is the present extent of contamination? • What is the projected extent of contamination? • Do present or projected contaminant levels exceed regulatory limits at (or beyond) the boundary of compliance? • What hazard is associated with no action? • Is containment or source control feasible? • Is treatment or resource recovery feasible? • Is removal action feasible? • What remedial actions appear to be appropriate? • What is the recommended alternative?

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Phase 1A RI work is scheduled to start prior to the formal approval of this work plan by the regulators. The RI work will be confined to noninvasive methods such as geophysical surveys. This is anticipated to be an iterative process: after each phase of the RI, existing data will be evaluated to assess any data gaps that must be addressed in the next phase of the data collection effort, and the DQOs will be revised accordingly. As the overall understanding of the site improves and the range of potential remedial alternatives is narrowed, data gaps should become more limited. Once candidate RA alternatives have been completely identified, fully defining all data needs for evaluation and comparison of alternatives should be possible.

4.3.1 Data Users

Data users can be subdivided into two general categories: primary and secondary. Primary data users are those individuals or organizations directly involved in ongoing RI/FS activities. These activities include the following:

- RI/FS planning and implementation
- Evaluation and interpretation of data
- Assessment of data needs and development of DQOs
- Identification and evaluation of treatment technologies and remedial alternatives
- Performance and risk assessment
- Project management and oversight
- Site-specific decision making.

Primary data users include the following:

- Remedial-project managers
- Unit managers from EPA, Ecology, and DOE
- RI and FS coordinators
- Technical contributors.

Secondary data users are those individuals or organizations who rely mainly on outputs from the RI/FS studies to support their activities. Secondary data users include the following:

- Agency for Toxic Substances and Disease Registry, for public health evaluation
- The general public and special-interest groups.

Most data needs are defined by primary data users. Secondary data users may also provide inputs to the decision makers and primary data users by communicating generic or site-specific data needs or regulatory requirements or by comment or question during the review process.

4.3.2 Data Uses

Most data uses during the RI/FS fall into one or more of four general categories:

- Site characterization
- Worker health and safety
- Public health evaluation and risk assessment
- Evaluation of remedial alternatives.

Site characterization refers to the determination and evaluation of the physical and chemical properties of the site, development and refinement of the conceptual model, and evaluation of the nature and extent of contamination. This category includes geologic, hydrologic, and meteorologic data as well as data on specific contaminants.

The worker health and safety category includes data collected to establish the level of protection for workers during various RI activities. In addition, these data are used to determine if there is concern for the population living in the vicinity of the site.

Data collected to conduct the public health evaluation and risk assessment include input parameters for various performance assessment models, site characteristics and contaminant data required to evaluate the threat to public health and welfare posed by the site.

Data collected to support evaluation of remedial alternatives include site characteristics and engineering data required for initial screening of alternatives, feasibility-level design, and preliminary cost estimates, as well as data required to support performance assessment.

4.3.3 Data Needs

Relatively little reliable data are presently available for the 1100 Area. Hence, the RI/FS is conducted in phases, and the goals of the initial phase are to locate any contamination, identify the contaminants, and make a determination as to whether or not regulatory criteria have been exceeded or if an immediate hazard to public health or welfare exists. Data uses to be accommodated by Phase 1A and 1B activities are primarily site characterization and worker health and safety. However, the importance of public health risk evaluation and the evaluation of remedial alternatives is recognized. After a contamination hazard is verified, specific contaminants are identified, and site characteristics are better known, later phases of the RI/FS will focus on evaluation of risk to human health and/or the

environment and identification and evaluation of remedial alternatives. These subsequent phases may not be necessary if contaminants resulting from waste disposal at individual sites do not exist at levels in excess of those specified by the ARARs and if no hazard to human health or the environment exists.

Individual data needs that must be satisfied to conduct a preliminary assessment of the hazard to human health and the environment are as follows.

- Determine nature and extent of contamination.
 - Locate areas of potential contamination: Obtain sufficient data to achieve a very high probability of locating a significant volume of contaminated soil.
 - Identify contaminants: Obtain sufficient samples and conduct appropriate analyses to achieve a very high probability of detecting the presence of any contaminant in either soil or groundwater.
 - Determine levels of contamination: Obtain sufficient media samples and conduct analyses with appropriate detection limit such that comparison with ARARs is possible. Obtain sufficient replicate samples, blanks, and spikes to estimate the precision and accuracy of the concentration data.
- Define conceptual model (site characterization).
 - Stratigraphy: Detect significant stratigraphic horizons and determine contacts between individual units.
 - Vadose zone: Determine or estimate vadose zone properties (infiltration, porosity, saturation, hydraulic conductivity, and specific retention) to the degree necessary to support preliminary modeling of contaminant transport.
 - Identify aquifers and aquitards: Identify significant aquifers and aquitards that control subsurface water flow and contaminant transport. Identify zones of perched water conditions.
 - Piezometric surface: Determine the depth to groundwater level at sufficient points to determine the magnitude and direction of hydrologic gradient for each site to a high level of confidence; monitor groundwater level and gradient with time.
 - Aquifer properties: Determine aquifer properties (porosity, transmissivity, hydraulic conductivity, storage coefficient, and dispersion coefficients) to the degree necessary to support preliminary modeling (modeling of the no-action alternative) of contaminant transport.

The specific sampling and analysis program to satisfy these data needs is discussed in Section 4.4.

4.3.4 Data Quality Objectives

The DQOs are qualitative and quantitative statements that specify the quality of data required to support decisions during remedial response activities. A variety of analytical methods are generally available to provide data. In general, increasing accuracy and precision are obtained with increasing cost and time. Therefore, the analytical level used to obtain data should be commensurate with the intended use. Table 4-2 defines five analytical levels based on overall data quality.

Table 4-2. Analytical Levels.

Level	Description
Level I	Field screening or analysis using portable instruments. Results are often not compound specific and not quantitative, but they are available in real time. This is the least costly of the analytical options. Instruments may not respond to all compounds and may not be able to identify compounds. If the instruments are calibrated properly and data are interpreted correctly, Level I techniques can provide an indication of contamination.
Level II	Field analyses using more sophisticated portable analytical procedures such as gas chromatography for organics and atomic absorption or X-ray fluorescence for metals. The instruments may be set up in a mobile laboratory on site. Results are available in real time or within several hours and may provide tentative identification of compounds or be analyte specific. Data are typically reported in concentration ranges, and detection limits may vary from low parts per million to low parts per billion. Data quality depends on the use of suitable calibration standards, reference materials, sample-handling procedures, and on the training of the operator. In general, Level II techniques and instruments are mostly limited to volatiles and metals.
Level III	All analyses performed at an offsite analytical laboratory. Level III analyses may or may not use contract laboratory program (CLP) procedures but do not usually use the validation or documentation procedures required of CLP Level IV analysis. Detection limits and data quality are similar to Level IV, but results will generally be available in a shorter time.
Level IV	Contract laboratory program routine analytical services. All analyses are performed in an offsite CLP analytical laboratory following CLP protocols. Generally low p/b detection limit for substances on the hazardous substance list but may also provide identification of compounds not on the hazardous substance list. Sample results may take several days to several weeks, and additional time may be required for data validation. Level IV results have known data quality supported by rigorous quality-assurance and quality-control protocols and documentation.
Level V	Analysis by nonstandard methods. All analyses are performed in an offsite analytical laboratory that may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits, and additional lead time may be required. Detection limit and data quality are method specific. The CLP special analytical services are Level V.

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Individual DQOs and appropriate analytical levels associated with each data need are given in Table 4-3. In general, DQOs for Phase 1 of the RI are intended to obtain data of sufficient quality and quantity to accomplish the following.

- Locate areas of contaminated soil or groundwater.
- Detect the presence of any contaminant, and determine its concentration level to the extent that a comparison to ARARs and other action levels can be made.
- Determine site characteristics, contaminant properties, and probable contaminant transport pathways to the degree required to support a preliminary risk assessment.
- Protect worker health and safety during RI activities.

Once completed, the comparison to ARARs and the preliminary risk assessment will be used to determine the following.

- Do any of the individual sites poses an immediate threat to human health or to the environment?
- Do any of the individual sites pose a potential long-term risk to human health or the environment such that future RI/FS work is warranted?
- What are the site controls and levels of protection required of workers for performance of future RI work and site remediation?

The primary decision to be made on the basis of the Phase 1 RI data is whether or not to continue the RI/FS process at each site. This decision can be stated in terms of an alternate statistical hypothesis (e.g., concentration levels within a specified volume of the site do not exceed action levels specified in ARARs). The decision will be to accept or reject the hypothesis on the basis of data obtained from the RI. For such a decision there are four possible outcomes.

- Decision is made not to implement RA when true conditions are such that RA is not required (correct decision).
- Decision is made to implement RA when true conditions are such that RA is required (correct decision).
- Decision is made not to implement RA when true conditions are such that RA is required (Type II error).
- Decision is made to implement RA when true conditions are such that RA is not required (Type I error).

Table 4-3. Data Quality Objectives. (Sheet 1 of 2)

Data need	Method	Analytical level	Data quality objective
Determine nature and extent of contamination			
Locate areas of contamination	Detailed site inspection	N/A	Locate surface expressions of waste burial areas, discolored soil, and areas of affected vegetation.
	Ground-probing radar	I	Achieve high degree of confidence in locating buried waste containers and significant volumes of disturbed soil.
	Electromagnetic survey	I	Locate variations in soil conductivity associated with the presence of contaminants or buried metallic objects.
	Soil resistivity	I	Locate lateral and vertical variations in soil resistivity associated with the presence of contaminants.
	Magnetometer	I	Locate buried ferrometallic waste containers such as steel drums.
	Metal detector	I	Locate buried metallic objects such as drums, tanks, or pipes.
	Radiological survey	I	Achieve a very high degree of confidence in locating areas of surface radioactive contamination.
Detect contaminants	Soil-gas survey	II-III	Detect and identify organic vapors in the vadose zone to the parts-per-billion range.
	Air quality monitoring	II-III	Achieve a high level of confidence in detecting and identifying any airborne contaminants emitted from the site(s), either at present or as a result of remedial investigation activities.
	Ambient air monitoring with flame ionization detectors, photo ionization detectors, or colormetric tubes	I	Achieve a very high degree of confidence in detecting contaminants, to protect worker health and safety.
	Radiological monitoring	I	Achieve a very high degree of confidence in detecting radionuclides, to protect worker health and safety.
	Groundwater monitoring wells	I	Measure and record water quality parameters during well purging.
Identify contaminants and determine concentration levels	Vadose zone holes and soil samples	II, III, or V	Obtain samples and test for organic and inorganic contaminants. Achieve high probability of detecting any potential contaminants present at levels defined in ARARs.
	Samples from monitoring wells and water supply wells	III or V	Obtain samples from monitoring wells and water supply wells. Test for organic and inorganic contaminants. Achieve a very high probability of detecting any potential contaminant with detection limits below action levels defined in ARARs.

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Table 4-3. Data Quality Objectives. (Sheet 2 of 2)

Data need	Method	Analytical level	Data quality objective
Support conceptual model development/preliminary risk assessment			
Contaminant source characteristics	See above		
Site stratigraphy	Geologic logs of vadose zone holes and groundwater monitoring wells	N/A	Define general stratigraphic and lithologic units in 1100 Area. Define contacts between units.
	Geophysical logs of groundwater monitoring wells	I	Correlate stratigraphic and lithologic units between holes.
Site hydrogeology	Geologic logs of vadose zone holes and groundwater monitoring wells	N/A	Identify aquifers and aquitards.
	Geophysical logs of groundwater monitoring wells	I	Identify aquifers and aquitards. Obtain rough estimates of in situ bulk density and porosity.
	Aquifer tests	N/A	Obtain rough estimates of aquifer transmissivity and storage coefficient.
Groundwater flow regime	Measure water levels in groundwater monitoring wells and selected vadose zone holes	I	Determine general hydraulic gradient in selected areas by solution of the three-point problem. Prepare contour maps of potentiometric surface to estimate direction and magnitude of hydraulic gradient.
Contaminant/soil interactions	Geochemical analysis of soils: leaching studies	III	Determine contaminant release rates and retardation properties of soils.
Vadose zone transport properties	Moisture characteristic curves for vadose zone soils	N/A	Determine hydraulic conductivity of vadose zone soils as a function of porosity and degree of saturation.
Perturbations to groundwater flow regime	Estimate contribution of specific perturbations	N/A	Determine impact of perturbations to groundwater flow regime (direction and rate of groundwater flow)

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For this decision, the consequences associated with a Type II error are much more serious than those associated with a Type I error. For example, the decision not to continue the RI/FS when remedial action is actually required would mean that a significant hazard to human health and/or the environment may continue to exist. On the other hand, conducting the RI/FS when remedial action is not required represents primarily a waste of resources (which may divert resources from other contaminated sites) but does not result in any risk to human health or the environment. Therefore, it is necessary to demonstrate that the probability of a Type II error is acceptably small. In other words, if no contaminants are found, the decision to terminate the RI/FS must be made to a high degree of confidence. On the other hand, if contaminants are found, the RI/FS will likely be continued. In this case, the only error possible is the Type I error, whose consequences are much less significant, at least in terms of risk to human health or the environment. Hence, the quantity and quality of data collected during Phases 1A and 1B of the RI must be sufficient to demonstrate the presence or absence of a particular contaminant to a high degree of confidence, but it is not necessary to determine the concentration or extent of contamination to the same level of confidence. The data necessary to fully evaluate concentration levels and to better define the extent of contamination can be obtained in later phases of the RI. In the event that a Type I error has been made, subsequent RI activities will provide sufficient data to detect the error, and the RI/FS can be discontinued at that time. This will result in the most cost-effective approach, because the data collection effort necessary to fully define the extent of contamination will only be undertaken if contamination is detected.

4.4 SAMPLING AND ANALYSIS PROGRAM

This section describes the field investigation program for the first phase of the RI. As indicated on Figure 1-2, there are additional phases of the RI that will be conducted as required to obtain specific data necessary to support FS activities. However, the requirements of the later phases of the RI cannot be completely defined at this time. Hence, the SAP will be revised to reflect the data obtained from the initial field investigation program defined herein.

There are three areas in which site investigation activities will be conducted. These are (1) vadose zone and groundwater, (2) air quality and meteorology, and (3) biota. The vadose zone and groundwater program will be subdivided into two phases, which are designated as RI Phase 1A and RI Phase 1B. The purpose of Phase 1A is to determine final locations for borings and monitoring wells based on nonintrusive survey techniques. The borings and monitoring wells will then be drilled in Phase 1B. Specific phases are less distinct for the air quality and meteorology program and the biota program. Sampling activities associated with these programs will be carried out concurrently with the vadose and groundwater program in the appropriate sequence.

4.4.1 Vadose Zone and Groundwater Characterization

Because of the proximity of the city of Richland wells and the importance of the groundwater pathway, the vadose zone and groundwater characterization program represents the bulk of the RI effort in Phase 1.

4.4.1.1 General Sampling Program. The field work will proceed in phases. These are designated as RI Phases 1A and 1B. In Phase 1A, the sites will be surveyed to lay out a sampling grid and to prepare accurate topographic maps of each site and the surrounding area. Each node (intersection of grid lines) will be marked in the field with a wooden stake. The spacing and orientation of the grid will be based on individual site characteristics. The next step will be to perform geophysical surveys of the waste sites. These geophysical surveys will include some or all of the following techniques: ground-penetrating radar, electromagnetic surveys, magnetometer surveys, or ground resistivity profiles and/or soundings. Following the geophysical surveys, a soil-gas survey will be conducted. The data obtained during the geophysical and soil-gas surveys can then be used to determine the final locations for vadose zone samples and groundwater monitoring wells.

The purpose of the geophysical surveys will be to determine the depth (and boundaries) of the various waste sites, locate buried metallic objects and structures (including mislocated pipes and utility lines as well as drums or other types of sample containers), and locate any anomalies that may indicate the presence of disturbed soil or contaminants. Table 4-4 indicates the uses of various geophysical methods. Geophysical surveys may be extended beyond the site boundaries if necessary to fully define subsurface conditions.

After the geophysical work is completed, soil-gas surveys will be conducted to detect and identify organic vapors within the pore space of the soil. A hollow probe is driven to a depth of approximately 5 ft, and an air sample is withdrawn for analysis by a gas chromatograph. Information from the soil-gas surveys will help identify areas with elevated levels of organic vapors that may be the result of volatile organic contaminants in the soil or migration of vapor from the groundwater through the soil. Additional sampling points outside of the site boundaries may be warranted to define the margin of any vapor plume.

Once the RI Phase 1A surveys are completed, the data will be evaluated, and the proposed vadose and groundwater sampling locations will be adjusted as required. Final locations of vadose zone sampling holes and groundwater monitoring wells will be chosen by the technical lead with the assistance of the technical staff so as to provide a maximum probability of detecting any contaminants, consistent with location constraints, health and safety considerations, and sampling objectives. The final number of sampling locations and monitoring wells in Phase 1B will depend on the number of anomalous areas detected during the Phase 1A surveys.

Table 4-4. Geophysical Techniques.

Method	Description	Use
Ground-penetrating radar	High-frequency electromagnetic waves transmitted into ground and reflected back to antenna.	Detect buried objects (drums, pipes, etc.). Detect zones of disturbed soil (trenches, etc.). Delineate near-surface stratigraphy and structure.
Soil resistivity profiling	Resistivity measurements made between electrodes with fixed spacing. Electrode array is moved along profile.	Detect and map lateral variations in soil resistivity. Map shallow contaminant plumes.
Soil resistivity sounding	Resistivity measurements made between electrodes with increasing spacing. Electrode array remains centered on a point while the spacing is increased.	Detect vertical variations in soil resistivity. Determine depth to groundwater and stratigraphy.
Electromagnetic surveys	Measures variations in induced magnetic fields resulting from variations in soil conductivity. Can be conducted in profiling or sounding mode.	Detect buried metallic objects (drums, pipes, etc.). Detect zones of disturbed soil (trenches, etc.). Detect and map variations in soil conductivity associated with stratigraphy and/or contaminant content.
Magnetometer surveys	Measures variations in natural magnetic field.	Detect buried metallic (ferrous) objects (drums, pipes, etc.).
Metal detectors	Measures local fluctuations in magnetic field.	Detect ferrous and nonferrous metals at relatively shallow depths. Depth of detection depends on size and magnetic characteristics of object.
Seismic refraction	Measures propagation time for seismic (acoustic) waves refracted along subsurface contacts between materials of contrasting seismic velocity.	Delineate subsurface stratigraphy and structure.

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Unless otherwise noted, vadose zone borings will be drilled using either cable-tool or hollow-stem auger rigs. Samples will be taken continuously from the surface to a depth of 20 ft using a drive tube or split barrel sampler. Below the 20-ft depth, samples will be taken every 5 ft to the saturated zone (anticipated to be at a depth of approximately 50 to 60 ft at most locations). In the event of no sample recovery or inadequate sample, the boring will be cleaned out to the bottom of the sampling interval, the sampler will be decontaminated, and another sampling attempt will be made before advancing the hole to the next sampling depth. Where appropriate, vadose borings will be completed as piezometers, to monitor groundwater level in the unconfined aquifer.

In addition to the vadose borings, additional composite samples will be obtained from near-surface soils by means of open-flight auger holes to

depths of approximately 10 ft. Hand-sampling methods may also be used where appropriate to obtain additional near-surface soil samples.

Groundwater monitoring wells will be drilled with cable tool rigs. Other drilling methods may be used if rigs are available. For most sites in the 1100 Area, the maximum depth of groundwater monitoring wells is anticipated to be approximately 80 to 100 ft, unless otherwise noted in the site-specific discussions below. Geologic samples will be obtained at 5-ft intervals to support hydrogeologic characterization of the well. Geophysical logs may be run as appropriate for characterization and correlation.

Groundwater samples will be collected from groundwater monitoring wells and existing wells in the 1100 Area on at least a quarterly basis for a minimum of 1 yr.

Field quality control samples will also be collected. These will include trip blanks, field blanks, and duplicates or replicates. Soil samples from vadose borings or groundwater monitoring wells in uncontaminated areas (e.g., upgradient) may be used as blanks where appropriate. Groundwater blanks will consist of distilled water. Field quality control samples are discussed in Section 5.0.

A preliminary summary of the vadose zone and groundwater sampling program for Phases 1A and 1B of the RI is presented in Table 4-5. The vadose and groundwater sampling program will be conducted in accordance with Westinghouse Hanford environmental investigation and site characterization procedures. A list of specific procedures and anticipated completion dates is given in Appendix C.

4.4.1.2 General Analytical Approach. In general, a broad-based analytical approach will be used to detect and identify contaminants. At present, no evidence of contaminants migrating from the 1100-EM-1 waste sites has been found. Because the waste disposal history at most of the sites is poorly known, the initial analytical approach must consider a broad range of possible contaminants. Since the present conceptual model indicates that the groundwater pathway is the most credible, much of the analytical effort will be devoted to evaluating the quality of the groundwater in the unconfined aquifer. It will also be important to identify areas of contaminated soil from which contaminants may be percolating toward the groundwater.

Groundwater samples will fall into the following four broad categories:

- Well-development samples
- "Presumptive-indicator" samples
- Primary and secondary drinking-water-quality samples
- Groundwater samples for detailed characterization.

Table 4-5. Summary of Vadose Zone and Groundwater Characterization Program.

Activity	Battery acid pit (1100-1)	Disposal pits (1100-2 and 3)	Antifreeze tank(1100-4)	Radiation contamination site (1100-5)	Horn Rapids landfill	"Discolored-soil" site
RI Phase 1A						
Survey and establish grid	(10 ft)	(40 ft)	N/A	N/A	(100 ft)	N/A
Radiological survey	X	X	N/A	X	X	N/A
Ground-penetrating radar survey (ft line)	100	3,800	N/A	N/A	19,000	N/A
Electromagnetic survey	N/A	X	N/A	N/A	X	N/A
Magnetometer	N/A	N/A	N/A	N/A	X	N/A
Metal detector	N/A	X	N/A	N/A	X	N/A
Soil-gas survey	6	173	N/A	N/A	110	N/A
RI Phase 1B						
Near-surface soil samples	N/A	60	N/A	N/A	30	10
Vadose zone holes	1	6	N/A	N/A	9	N/A
Groundwater monitoring wells	2	4	1	N/A	10	N/A
Soil samples (total)	71	114	20	N/A	201	10
Physical analysis	45	60	10	N/A	90	N/A
Chemical analysis (soil)	23	54	0	N/A	111	10
Geochemical analysis	3	6	N/A	N/A	9	N/A
Water samples	3	4	1	N/A	10	N/A
Aquifer tests	1	3	N/A	N/A	6	N/A

Field chemical analysis during well purging or development pumping is necessary to ensure that groundwater samples sent to the laboratory for more complete analysis are representative of formation conditions. Usually, a decision that well purging is reasonably complete is based on stabilization of a set of parameters that includes pH, temperature, specific conductance, and turbidity.

Presumptive indicator parameters are compounds likely to be associated with the presence of a contaminant plume. The choice of appropriate parameters is based on the waste-disposal history for each site and on the Washington Administrative Code, which specifies indicator parameters (Table 4-6).

Table 4-6. Indicator Parameters for Landfill.

A.	Temperature
B.	Conductivity
C.	pH
D.	Chloride
E.	Nitrate, nitrite, and ammonia as nitrogen
F.	Sulfate
G.	Dissolved iron
H.	Dissolved zinc and manganese
I.	Chemical oxygen demand
J.	Total organic carbon
K.	Total coliform

Source: WAC 173-304-490 (Ecology 1987b, p. 401).

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These parameters have been chosen for plume detection, but not necessarily to provide chemical characterization. In other words, when the indicator parameters fall outside specified ranges, it can be taken as an indication that the water is contaminated, but does not necessarily indicate the type and degree of contamination.

In addition to the indicator parameters of Table 4-6, total organic halogen (TOX) should be included as an indicator parameter, since many of the suspected contaminants are halogenated solvents. Ethylene glycol and sulfate may also be considered as indicator parameters.

Confirmation that groundwater quality has or has not been affected by waste disposal must also be based on comparison to regulatory standards. Table 4-7 lists primary and secondary drinking-water standards.

Table 4-7. Primary and Secondary Drinking-Water Standards. (Sheet 1 of 2)

Primary drinking-water standards (40 CFR 141) (EPA 1986a)	
Inorganic compounds	Maximum contaminant levels (mg/L)
Arsenic	0.05
Barium	1.0
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.0
Selenium	0.01
Silver	0.05
Organic compounds	Maximum contaminant levels (mg/L)
Chlorinated hydrocarbons	
Endrin (1,2,3,4,10,-10-hexachloro-6,7-epoxy-1,4, 4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano naphthalene)	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)	
Methoxychlor (1,1,1-Trichloro-2, 2-bis [p-methoxyphenyl] ethane)	0.004
Toxaphene (C ₁₀ H ₁₀ Cl ₈ -Technical chlorinated camphene, 67-69% chlorine)	0.1
	0.005
Chlorophenoxys	
2,4-D (2,4-Dichlorophenoxyacetic acid)	
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid)	0.1
	0.01
Total Inhalomethanes [the sum of the concentrations of bromo-dichloromethane, dibromochloromethane, tribromomethane (bromoform) and trichloromethane (chloroform)]	
	0.10 meq/L
Volatile organic compounds	Maximum contaminant levels (mg/L)
Benzene	0.005
Vinyl chloride	0.002
Carbon tetrachloride	0.005
1,2-Dichloroethane	0.005
Trichloroethylene	0.005
para-Dichlorobenzene	0.075
1,1-Dichloroethylene	0.007
1,1,1-Trichloroethane	0.2

Table 4-7. Primary and Secondary Drinking-Water Standards. (Sheet 2 of 2)

Primary drinking-water standards	
Radionuclides	Maximum contaminant levels
²²⁶ Ra and ²²⁸ Rh Gross alpha ³ H (tritium) ⁹⁰ Sr	5 pCi/L 15 pCi/L 20,000 pCi/L 8 pCi/L
Secondary drinking-water standards (40 CFR 143) (EPA 1987d)	
Contaminants	Maximum contaminant levels
Chloride Color Copper Corrosivity Fluoride Foaming agents Iron Manganese Odor pH Sulfate Total dissolved solids Zinc	250 mg/L 15 color units 1 mg/L Noncorrosive 2.0 mg/L 0.5 mg/L 0.3 mg/L 0.05 mg/L 3 threshold odor number 6.5-8.5 250 mg/L 500 mg/L 5 mg/L

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In addition to the above analyses, both groundwater and soil samples will be subjected to a suite of analyses designed to detect a broad range of possible contaminants. Table 4-8 indicates specific analytical procedures by medium. The U.S. Testing Statement of Work for Hazardous Chemical Analytical Services is included as Appendix D. Sample quantities, preparation and preservation techniques, and sample holding times will be consistent with the requirements of individual analytical methods. The scope of the initial analyses will be to detect and identify compounds on the contract laboratory program (CLP) target compound list. This list is presented in Table 4-9. In addition, specific analyses will be conducted as appropriate to detect and quantify known or suspected contaminants at each site. As analytical data become available, it is anticipated that the scope of the analytical program can be narrowed to address primarily indicator compounds. An indicator compound will generally be a contaminant present near or above action levels established by the ARARs, for which it is anticipated that remedial action may be required or for which a risk assessment must be conducted. However, it is anticipated that most of the analytical samples collected in Phase 1B will be analyzed for the entire target compound list, with recommendations as to indicator compounds included in the Phase 1 RI report.

Table 4-8. Analytical Methods.

Extraction	Analytical method	Analytes
Soil-gas		
--	GC/FID GC/ECD	Volatile organic compounds Volatile halogenated compounds
Soil		
Extraction procedure on fraction less than 9.5 mm [1310]	ICP [6010] AA [7470] GC/ECD [8080] GC/ECD [8150]	Metals Mercury Organochlorine pesticides and PCBs Chlorinated herbicides
Purge and trap on sand/silt/clay fraction	GC/MS [8240]	Volatile organic compounds
Soxhlet extraction [3540] or sonication [3550] on sand/silt/clay fraction	GC/MS [8270]	Semivolatile organic compounds
Water		
Acid digestion [3005]	ICP [6010] AA [various]	Metals Specific metals
Purge and trap	GC/MS [8240]	Volatile organic compounds
Separatory funnel [3510]	GC/MS [8270] GC/ECD [8080]	Semivolatile organic compounds Organochlorine pesticides and PCBs
--	GC/ECD [8150]	Chlorinated herbicides
--	GC/MS [8280]	Dioxins
Carbon absorption	Microcoulometric titration [9020]	Total organic halogen
--	Carbonaceous analyzer [9060]	Total organic carbon
--	GC (direct aqueous injection)	Ethylene glycol
--	Ion chromatography (ASTM D4327-84) (ASTM 1984)	Bromide, chloride, fluoride, nitrate, nitrite, phosphate, sulfate

AA = atomic absorption.
 ECD = electron capture detector.
 FID = flame ionization detector.
 GC = gas chromatography.
 ICP = inductively coupled plasma.
 MS = mass spectroscopy.
 [] = EPA method (See EPA 1986c).

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Table 4-9. Target Compound List and Contract Required Quantitation Limits. (Sheet 1 of 6)

	Chemical Abstract Services number	Quantitation limits ^a	
		Water (µg/L)	Low soil/ sediment ^{b, c, d} (µg/kg)
Volatiles			
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene chloride	75-09-2	5	5
6. Acetone	67-64-1	10	10
7. Carbon disulfide	75-15-0	5	5
8. 1,1-dichloroethene	75-35-4	5	5
9. 1,1-dichloroethane	75-34-3	5	5
10. 1,2-dichloroethene (total)	540-59-0	5	5
11. Chloroform	67-66-3	5	5
12. 1,2-dichloroethane	107-06-2	5	5
13. 2-Butanone	78-93-3	10	10
14. 1,1,1-trichloroethane	71-55-6	5	5
15. Carbon tetrachloride	56-23-5	5	5
16. Vinyl acetate	108-05-4	10	10
17. Bromodichloromethane	75-27-4	5	5
18. 1,2-dichloropropane	78-87-5	5	5
19. cis-1,3-dichloropropene	10061-01-5	5	5
20. Trichloroethene	79-01-6	5	5
21. Dibromochloromethane	124-48-1	5	5
22. 1,1,2-trichloroethane	79-00-5	5	5
23. Benzene	71-43-2	5	5
24. trans-1,3-dichloropropene	10061-02-6	5	5
25. Bromoform	75-25-2	5	5
26. 4-methyl-2-pentanone	108-10-1	10	10

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Table 4-9. Target Compound List and Contract Required Quantitation Limits. (Sheet 2 of 6)

	Chemical Abstract Services number	Quantitation limits ^a		
		Water (µg/L)	Low soil/ sediment ^b (µg/kg)	
Volatiles (cont.)				
27.	2-hexanone	591-78-6	10	10
28.	Tetrachloroethene	127-18-4	5	5
29.	Toluene	108-88-3	5	5
30.	1,1,2,2-tetrachloroethane	79-34-5	5	5
31.	Chlorobenzene	108-90-7	5	5
32.	Ethyl benzene	100-41-4	5	5
33.	Styrene	100-42-5	5	5
34.	Xylenes (total)	1330-20-7	5	5
Semivolatiles				
35.	Phenol	108-95-2	10	330
36.	bis (2-chloroethyl) ether	111-44-4	10	330
37.	2-chlorophenol	95-57-8	10	330
38.	1,3-dichlorobenzene	541-73-1	10	330
39.	1,4-dichlorobenzene	106-46-7	10	330
40.	Benzyl alcohol	100-51-6	10	330
41.	1,2-dichlorobenzene	95-50-1	10	330
42.	2-methylphenol	95-48-7	10	330
43.	bis (2-chloroisopropyl) ether	108-60-1	10	330
44.	4-methylphenol	106-44-5	10	330
45.	N-nitroso-di-n-dipropylamine	621-64-7	10	330
46.	Hexachloroethane	67-72-1	10	330
47.	Nitrobenzene	98-95-3	10	330
48.	Isophorone	78-59-1	10	330
49.	2-nitrophenol	88-75-5	10	330
50.	2,4-dimethylphenol	105-67-9	10	330
51.	Benzoic acid	65-85-0	50	1,600
52.	bis (2-chloroethoxy) methane	111-91-1	10	330

PST88-3340-4-6

Table 4-9. Target Compound List and Contract Required Quantitation Limits. (Sheet 3 of 6)

	Chemical Abstract Services number	Quantitation limits ^a	
		Water (µg/L)	Low soil/ sediment ^{b, c, d} . (µg/kg)
Semivolatiles (cont.)			
53. 2,4-dichlorophenol	120-83-2	10	330
54. 1,2,4-trichlorobenzene	120-82-1	10	330
55. Naphthalene	91-20-3	10	330
56. 4-chloroaniline	106-47-8	10	330
57. Hexachlorobutadiene	87-68-3	10	330
58. 4-chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
59. 2-methylnaphthalene	91-57-6	10	330
60. Hexachlorocyclopentadiene	77-47-4	10	330
61. 2,4,6-trichlorophenol	88-06-2	10	330
62. 2,4,5-trichlorophenol	95-95-4	50	1,600
63. 2-chloronaphthalene	91-58-7	10	330
64. 2-nitroaniline	88-74-4	50	1,600
65. Dimethylphthalate	131-11-3	10	330
66. Acenaphthylene	208-96-8	10	330
67. 2,6-dinitrotoluene	606-20-2	10	330
68. 3-nitroaniline	99-09-2	50	1,600
69. Acenaphthene	83-32-9	10	330
70. 2,4-dinitrophenol	51-28-5	50	1,600
71. 4-nitrophenol	100-02-7	50	1,600
72. Dibenzofuran	132-64-9	10	330
73. 2,4-dinitrotoluene	121-14-2	10	330
74. Diethylphthalate	84-66-2	10	330
75. 4-chlorophenyl-phenyl ether	7005-72-3	10	330
76. Fluorene	86-73-7	10	330
77. 4-nitroaniline	100-01-6	50	1,600
78. 4,6-dinitro-2-methylphenol	534-52-1	50	1,600

PST88-3348-4-6

Table 4-9. Target Compound List and Contract Required Quantitation Limits. (Sheet 4 of 6)

	Chemical Abstract Services number	Quantitation limits ^a	
		Water (µg/L)	Low soil/ sediment ^{c, d} (µg/kg)
Semivolatiles (cont.)			
79. N-nitrosodiphenylamine	86-30-6	10	330
80. 4-bromophenyl-phenylether	101-55-3	10	330
81. Hexachlorobenzene	118-74-1	10	330
82. Pentachlorophenol	87-86-5	50	1,600
83. Phenanthrene	85-01-8	10	330
84. Anthracene	120-12-7	10	330
85. Di-n-butylphthalate	84-74-2	10	330
86. Fluoranthene	206-44-0	10	330
87. Pyrene	129-00-0	10	330
88. Butylbenzylphthalate	85-68-7	10	330
89. 3,3'-dichlorobenzidine	91-94-1	20	660
90. Benzo(a)anthracene	56-55-3	10	330
91. Chrysene	218-01-9	10	330
92. bis(2-ethylhexyl)phthalate	117-81-7	10	330
93. Di-n-octylphthalate	117-84-0	10	330
94. Benzo(b)fluoranthene	205-99-2	10	330
95. Benzo(k)fluoranthene	207-08-9	10	330
96. Benzo(a)pyrene	50-32-8	10	330
97. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
98. Dibenz(a,h)anthracene	53-70-3	10	330
99. Benzo(g,h,i)perylene	191-24-2	10	330
Pesticides/polychlorinated biphenyls			
100. alpha-BHC	319-84-6	0.05	8.0
101. beta-BHC	319-85-7	0.05	8.0
102. delta-BHC	319-86-8	0.05	8.0
103. gamma-BHC (lindane)	58-89-9	0.05	8.0
104. Heptachlor	76-44-8	0.05	8.0

PST88-3340-4-6

Table 4-9. Target Compound List and Contract Required Quantitation Limits. (Sheet 5 of 6)

	Chemical Abstract Services number	Quantitation limits ^a	
		Water (µg/L)	Low soil/ sediment ^{b,c,d} (µg/kg)
Pesticides/polychlorinated biphenyls (cont.)			
105. Aldrin	309-00-2	0.05	8.0
106. Heptachlor epoxide	1024-57-3	0.05	8.0
107. Endosulfan I	959-98-8	0.05	8.0
108. Dieldrin	60-57-1	0.10	16.0
109. 4,4'-DDE	72-55-9	0.10	16.0
110. Endrin	72-20-8	0.10	16.0
111. Endosulfan II	33213-65-9	0.10	16.0
112. 4,4'-DDD	72-54-8	0.10	16.0
113. Endosulfan sulfate	1031-07-8	0.10	16.0
114. 4,4'-DDT	50-29-3	0.10	16.0
115. Methoxychlor	72-43-5	0.5	80.0
116. Endrin ketone	53494-70-5	0.10	16.0
117. alpha-chlordane	5103-71-9	0.5	80.0
118. gamma-chlordane	5103-74-2	0.5	80.0
119. Toxaphene	8001-35-2	1.0	160.0
120. Aroclor-1016	12674-11-2	0.5	80.0
121. Aroclor-1221	11104-28-2	0.5	80.0
122. Aroclor-1232	11141-16-5	0.5	80.0
123. Aroclor-1242	53469-21-9	0.5	80.0
124. Aroclor-1248	12672-29-6	0.5	80.0
125. Aroclor-1254	11097-69-1	1.0	160.0
126. Aroclor-1260	11096-82-5	1.0	160.0

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Table 4-9. Target Compound List and Contract Required Quantitation Limits. (Sheet 6 of 6)

Analyte	Contract-required detection limit (µg/L)
Inorganic target analyte list	
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5,000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5,000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5,000
Selenium	5
Silver	10
Sodium	5,000
Thallium	10
Vanadium	50
Zinc	20
Cyanide	10

NOTE: Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

^aQuantitation limits listed for soil/sediment are based on wet weight and concentration in extractant. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

^bMedium soil/sediment contract-required quantitation limits (CRQL) for volatile target compound list compounds are 125 times the individual low soil/sediment CRQL.

^cMedium soil/sediment CRQLs for semivolatile target compound list compounds are 60 times the individual low soil/sediment CRQL.

^dMedium soil/sediment CRQLs for pesticide/polychlorinated biphenyls target compound list compounds are 15 times the individual low soil/sediment CRQL.

PST88-3348-4-6

The soil-gas survey will be the primary means of detection for volatile organic compounds in soils. These compounds may be the result of disposal of solvents, degreasers, waste oil, gasoline, paint thinner, or other substances associated with vehicle maintenance operations.

Soil samples from vadose zone holes and near-surface soil samples obtained using hand-sampling techniques or open-flight auger rigs will be analyzed to detect metals and less volatile organic compounds. In general, analyses will be conducted on liquid extracts from the sand/silt/clay fraction of the soil sample, using inductively coupled plasma to determine metals and gas chromatography/mass spectroscopy to determine organic compounds. Specific analytical procedures are listed on Table 4-8. Where appropriate, additional analytical procedures will be implemented to detect specific compounds. An example would be the use of atomic absorption to determine lead and/or cadmium content in samples taken from the battery acid pit. Selected soil samples may also be subjected to the extraction procedure or toxicity-characteristic leaching procedure; the resulting extractant will be analyzed to detect a wide range of contaminants.

Groundwater samples will be subject to analysis by gas chromatography/mass spectroscopy to determine volatile and semivolatile organic compounds. Other gas chromatography analyses will be conducted for pesticides and PCBs, herbicides, and dioxins. Analysis for metals will be carried out by inductively coupled plasma or atomic absorption. Anions will be determined by ion chromatography.

In addition to the chemical analyses discussed above, soil samples will also be tested for physical properties pertinent to characterization and evaluation of remedial alternatives. Physical properties of interest during the initial RI include particle size, moisture content, bulk density, water retention, hydraulic conductivity and diffusivity, and cation exchange capacity. Specific test procedures are indicated on Table 4-10.

Aquifer testing will be conducted to estimate in situ aquifer properties required for contaminant transport modeling. Aquifer tests will be carried out in accordance with aquifer test procedures included in the Westinghouse Hanford environmental investigation and site characterization procedures (see Appendix C).

In terms of location and site characteristics, the 1100-EM-1 waste sites can be subdivided into four groups. The specific sampling and analysis program for each group of sites will be discussed below.

4.4.1.3 Battery Acid Pit (1100-1) and Antifreeze Tank (1100-4). The battery acid pit and the antifreeze tank sites are both located in the vicinity of the 1171 building, which is the vehicle maintenance facility for the Hanford Site. Since the sites are relatively close together, they will be combined for the purposes of the vadose zone and groundwater investigation program. Contaminants of concern in this area are compounds associated with routine vehicle maintenance operations. Materials known to have been disposed to the soil column are sulfuric acid (containing lead and cadmium compounds) and ethylene glycol. Other compounds that may have been disposed include solvents, gasoline, waste engine and hydraulic oil (possibly containing PCBs), and degreasers.

Table 4-10. Physical Tests for Soil Samples.

Physical test	Location
"Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)"	Annual Book of ASTM Standards, Vol. 4.08, ASTM D2488 (ASTM 1986b).
"Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures"	Annual Book of ASTM Standards, Vol. 4.08, ASTM D2216 (ASTM 1986a).
"Bulk Density"	Methods of Soil Analysis, Part 1 (American Society of Agronomy 1986a).
"Water Retention: Laboratory Methods"	Methods of Soil Analysis, Part 1 (American Society of Agronomy 1986c).
"Hydraulic Conductivity and Diffusivity: Laboratory Methods"	Methods of Soil Analysis, Part 1 (American Society of Agronomy 1986b).
"Cation Exchange Capacity"	Methods of Soil Analysis, Part 2 (American Society of Agronomy 1982).

PST89-3024-5

The primary objective of the vadose and groundwater investigation program in the vicinity of the 1171 Building is to detect and identify any contaminants in the vadose zone or unconfined aquifer, to determine site stratigraphy and soil characteristics, and to determine the groundwater flow gradient and permeability of the unconfined aquifer. This will provide data for preliminary risk assessment and identification of appropriate remedial technologies. Additional site characterization work may be required later, depending on the nature of the contamination hazard and the requirements of the remedial technologies under consideration.

During the approximate period of 1957 to 1977, spent battery acid was discharged into an unlined pit (i.e., dry sump or French drain) located near the southwest corner of the 1171 Building. The area slopes very slightly toward the west and south along the railroad tracks, which are approximately 50 ft to the west. The exact location and size of the pit is not known, although estimates by motor-pool workers range from 5 to 12 ft in diameter and 5 to 10 ft deep. The pit was located approximately 15 ft south of the emergency shower.

A total of 15,000 gal of battery acid are estimated to have been dumped into the pit, based on extrapolation of present vehicle fleet usage rates. This is likely to be relatively conservative (high), because it assumes a constant fleet size of 2,000 vehicles over a 20-yr period and assumes that all of the spent battery acid was dumped into the pit. Although battery acid

is the only substance known to have been dumped into the pit, the proximity to vehicle maintenance operations suggests that other contaminants may have also been dumped into the pit, but no record of such disposal exists. Two surface soil samples obtained from the vicinity of the battery acid pit in March 1988 were found to contain elevated levels of lead. The results of these analyses are discussed further in Appendix B.

Until 1986, waste antifreeze was discharged to a 5,000-gal holding tank under the northeast corner of the 1171 Building. This tank was taken out of service and removed in 1986. It is suspected of having leaked. However, soil samples taken at the time the tank was exhumed did not contain detectable levels of ethylene glycol.

Ground surface elevation in the vicinity of the 1171 Building is approximately 400 ft above sea level. Geologic conditions are not well known. As indicated on Figure 4-5, the strata underlying the 1100 Area above the basalt include the Pasco Gravels of the Hanford formation and the Ringold Formation. Figure 4-7 shows the driller's log for well 3000-D-1 (1199-S41-13C), which is located approximately 3,000 ft to the north-northeast. This log suggests that the upper 5 ft is sand, with gravel and sandy gravel present to a depth of approximately 85 ft (elevation approximately 320 ft above sea level), where brown silt or clay is encountered. This silt/clay layer in the Ringold Formation appears to be laterally extensive and probably acts as an aquiclude, defining the lower boundary of the unconfined aquifer. The groundwater level in the unconfined aquifer is at a depth of approximately 50 ft.

The only credible transport mechanism for contaminants is percolation through the soil column to the groundwater in the unconfined aquifer. The public water supply wells located in the north Richland well field (approximately 1/2 mi to the east) and the Duke well field (approximately 3/4 mi to the southeast) are the most credible receptors. Although local groundwater flow conditions are not known, the regional gradient is west to east. Therefore it is assumed for the present that the direction of groundwater travel is toward the north Richland well field.

No soil samples or geophysical surveys are planned in the vicinity of the antifreeze tank. A soil sampling effort may be required later if ethylene glycol is detected in water samples from well MW-3, or if further evaluation of the samples taken at the time the tank was removed indicate that a higher level of data quality is required. However, this will involve removal of part of the floor in the 1171 Building and significant disruption of vehicle maintenance operations.

Figure 4-8 shows the location of geophysical traverses, soil-gas points, and vadose zone holes in the vicinity of the battery acid pit. Geophysical traverses using ground-penetrating radar will be conducted first to locate the pit. It is anticipated that two orthogonal traverses over the assumed pit location will be sufficient to define the boundaries of the pit. In the event that the ground-penetrating radar traverses do not adequately define the pit, consideration will be given to soil resistivity profiling to detect

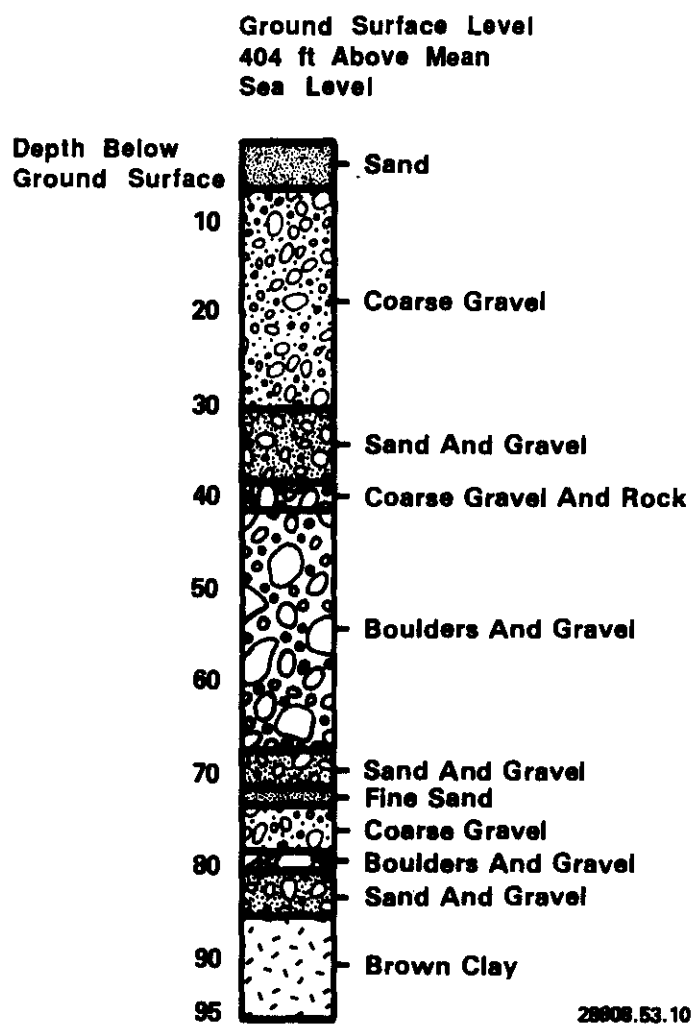


Figure 4-7. Driller's Log for Well 1199-S41-13C (3000-D-1).

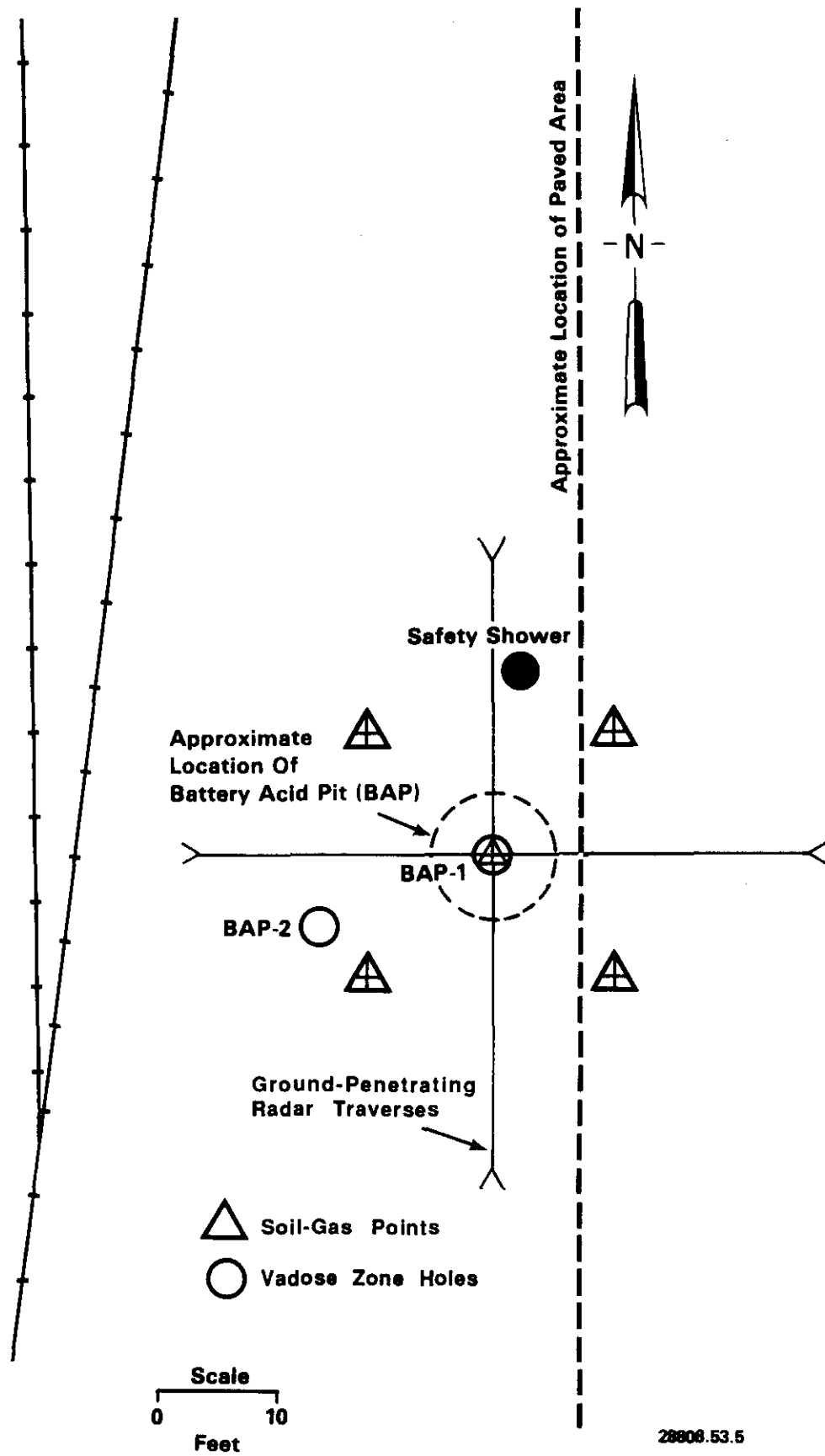


Figure 4-8. Vadose Zone Sampling Plan for the Battery Acid Pit.

lateral variations in soil resistivity associated with the acid. Other geophysical methods such as electromagnetic surveys were not considered because of the proximity to various cultural interferences such as power lines, buried pipelines, and railroad tracks.

Once the pit has been located, a limited soil-gas survey will be conducted. The purpose of the soil-gas measurements is to detect and identify any volatile organic vapors present in the near surface. This will provide some indication as to whether other substances such as solvents, gasoline, etc., were disposed of in or near the battery acid pit.

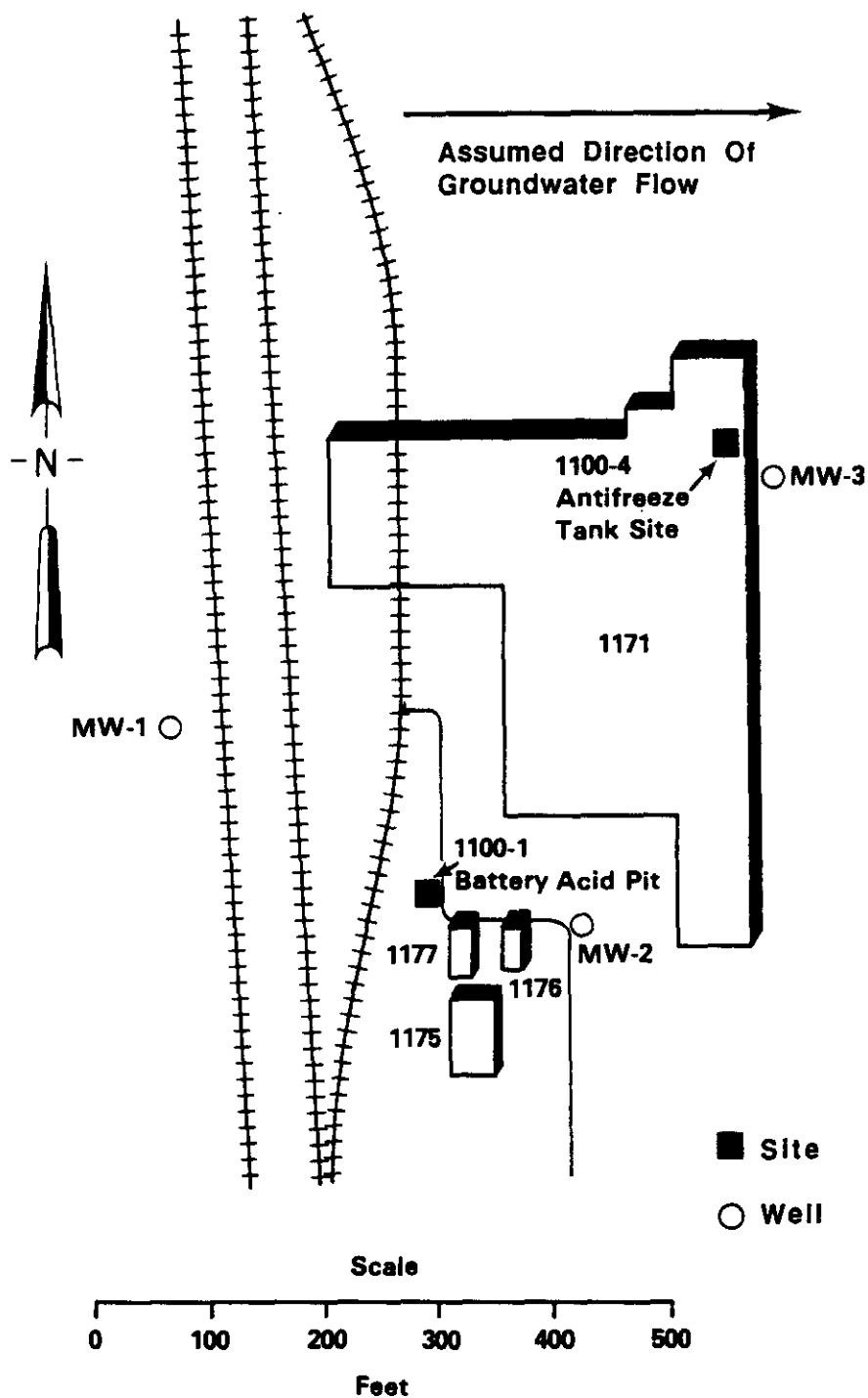
One vadose-zone hole (BAP-1) will be drilled at the center of the pit, as indicated by the geophysical survey and visual evidence. This hole will be sampled continuously to a depth of 20 ft, with samples at 5-ft intervals from 20 ft to the groundwater level (anticipated to be at 50 to 55 ft). It will be completed as a piezometer to provide water-level measurements.

In the event that the proportion of cobbles and boulders is too great for adequate sample recovery from boreholes, consideration will be given to digging a test pit with a backhoe. Representative samples will be obtained from the backhoe bucket to avoid personnel access into potentially unstable pits. Although backhoe pits are limited to a maximum depth of approximately 15 ft, this should be adequate to determine the presence of contamination in the vadose zone.

Soil samples will be classified in the field in accordance with Westinghouse Hanford geologic logging procedures (see Appendix C). Natural moisture content will be noted and calcium carbonate content will be estimated by noting the reaction to dilute hydrochloric acid.

The primary contaminants of concern at the battery acid pit are lead and cadmium. Data required to support preliminary risk assessment include concentration and extent of contamination as well as mobility of the lead and cadmium compounds under in situ conditions. Therefore, chemical analyses of soil samples will be oriented toward determination of lead and cadmium values, although the analytical effort will also include screening for other inorganic and organic compounds. In addition to the analytical procedures included on Table 4-8, soil samples will be subjected to acid digestion (EPA Method 3550) (EPA 1986c) and analyzed for lead and cadmium using atomic absorption techniques (EPA Methods 7421 and 7131, respectively) (EPA 1986c).

Three monitoring wells will be installed in the vicinity of the 1171 Building. The locations of these wells are shown on Figure 4-9. They are located so as to obtain a measurement of water level at three non-colinear points and to obtain samples downgradient of each waste site as well as upgradient. These wells will be drilled using cable-tool, rotary, or rotary-percussion equipment. Since the 1171 Building is an operating vehicle-maintenance facility, some consideration must be given to interference with operations. For example, a monitoring well located in the middle of a roadway will restrict or impede traffic flow, and will likely be subject to damage from vehicular traffic. Given the lack of precise data regarding aquifer properties and groundwater flow direction or travel time, it is



Note: Locations shown are approximate

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Figure 4-9. Monitoring Well Locations.

impossible to make any reliable statements regarding probable plume location at this time. Hence, operational considerations will control well location to some extent. As data become available, however, it may be necessary to locate additional wells without regard to interference with operations.

Two monitoring wells will be installed in the vicinity of the battery acid pit. The first well (MW-1) will be located about 230 ft to the west-northwest of the battery acid pit. The primary justification for this distance is access: the presence of active railroad lines precludes a closer location. This well will serve as a background location for both vadose zone and groundwater samples. This well will be drilled to the top of basalt (estimated to be at approximately 170- to 180-ft depth) to define hydrostratigraphic relationships in the vicinity of the 1171 Building. However, the monitoring well will be completed with the screen installed in the unconfined aquifer (estimated maximum depth of 80 to 90 ft). Samples will be obtained using a split barrel or drive tube sampler at 0-, 2-, and 5-ft depths, at 5-ft intervals from 5 ft to 100 ft, and at 10-ft intervals from 100 ft to total depth. Additional samples will be taken at each strata change.

The second well, MW-2, will be located approximately 130 ft to the east of the battery acid pit. The location of this well is also constrained by access considerations: the final location will be chosen to minimize interference with operations, while remaining outside of and downgradient from the zone of probable vadose contamination. While the local groundwater gradient is not known, the well will be located consistent with the regional gradient and between the battery acid pit (source) and the north Richland well field (receptor). MW-2 will be drilled to the silt/clay layer (anticipated depth of 80 to 90 ft, see Fig. 4-7) and completed in the unconfined aquifer.

A third groundwater monitoring well, MW-3, will be located east of the antifreeze tank site (1100-4). This well will also be located so as to minimize interference and is intended to intercept any contaminant plume moving from the antifreeze tank site in the direction of the north Richland well field. MW-3 will be drilled to the silt/clay layer (anticipated depth of 80 to 90 ft, see Fig. 4-7) and completed in the unconfined aquifer. Although vadose zone samples will be obtained for geologic characterization, they will not be analyzed for contaminants because the well is too far from the tank location. Water samples will be collected and analyzed for ethylene glycol by gas chromatography (direct aqueous injection), in addition to the suite of tests listed in Table 4-8.

The three wells in the vicinity of the 1171 Building are located in such a way that water-level measurements can be combined to obtain an indication of the groundwater flow direction and gradient in the vicinity of the 1171 Building. An additional water-level point will be available at the piezometer installed in the vadose boring at the battery acid pit. These data will be useful in siting any additional monitoring wells that may be required in later phases of the RI.

The completion details for the groundwater-monitoring wells will depend on conditions encountered. Based on the driller's log for well 3000-D-1 (Fig. 4-7), the depth to the water table is approximately 55 ft, and the

unconfined aquifer appears to have a saturated thickness on the order of 30 ft. For this situation, a screened interval of 20 ft is proposed, with at least 15 ft set below the static water level. A screen length of 15 ft within the aquifer will allow for large fluctuations in water level. However, the final screen length and screen set depth will be adjusted as appropriate to accommodate local hydrogeologic conditions encountered in the well.

Estimates of aquifer properties will be made as the wells are drilled by means of rising or falling head slug tests or drawdown and recovery tests. Procedures for these tests are included in the Westinghouse Hanford environmental investigation and site characterization procedures (see Appendix C).

4.4.1.4 Radiation Contamination Site (1100-5). This site is the location of a minor radiation contamination incident. On August 24, 1962, contamination was discovered on an incoming 16-ton cask and truck trailer when it arrived at the 1100 Area receiving facility. At the time the contamination was discovered the trailer was parked "in the parking lot northwest of the 1171 building." The radiation incident report notes that the leaking water had wet an area of approximately 1-ft dia on the trailer bed. Contamination was also noted on the underside of the trailer bed. No mention is made of ground surface contamination in the 1100 Area. Hanford Site policy at the time was (and is) that no site would be unconditionally released if any contamination were present. Therefore, the probability that a significant area of surface contamination in the 1100 Area went unnoticed is considered remote.

There is no evidence to suggest that large quantities of contaminated water were discharged. Subject to further investigation of survey records and personnel interviews, the possibility of migration of radionuclides to the unconfined aquifer is considered to be nil. Therefore, the only RI activity of this site will be a vehicle-mounted radiological survey of the parking lot to detect any areas of surface contamination.

4.4.1.5 Disposal Pits (1100-2, 1100-3 and "Discolored-Soil" Site). These sites are considered together because of similar characteristics. Each represents the location where liquid wastes may have been disposed of by dumping on the ground surface. At 1100-2 and 1100-3 there is a possibility of buried drums, but this is not considered likely. Each site is thought to consist of localized areas from which contaminants are percolating down to the unconfined aquifer.

The paint and solvent pit (1100-2) and antifreeze and degreaser pit (1100-3) are located in close proximity and have generally similar characteristics. Hence, they will be discussed in terms of a single conceptual model, with any significant differences in the two sites noted. The relative locations of the two pits are shown on Figures 2-1 and 4-3.

The paint and solvent pit (1100-2) is reported to have received irregular disposal of paints, paint thinners, and solvents in addition to miscellaneous construction waste from 1954 to 1985. The pit is an elongated shape approximately 250 ft long, 100 ft wide, and 5 to 6 ft deep, which lies along the east side of the railroad tracks. A dirt road runs along the base of the railroad ballast, enters the pit on the southwest, and crosses to the north,

where it emerges from the pit and joins a dirt road that generally follows an old railroad alignment parallel to Stevens Drive east of the pit. The pit is located approximately 300 ft west of Stevens Drive. There is no visible evidence of paint, solvent, or discolored soil on the surface in the vicinity of this site. The exact locations of paint and solvent disposal at this site are unknown. No chemical inventory is available. Analyses of two surface soil samples obtained in March 1988 reveal no evidence of contamination. The volume of paint thinner and other solvents disposed of in the pit is estimated to be on the order of 100 gal/yr, or approximately 3,000 gal over the 30-yr history of the pit.

The antifreeze and degreaser pit (1100-3) is reported to have received irregular disposal of antifreeze and degreasing solvents from 1979 to 1985. It is an approximately circular depression about 250 ft in diameter and 8 to 12 ft deep. Access to the pit is by means of a dirt road that enters from the southwest. It is reported to have been an excavation for sand and gravel borrow material, with the bottom of the original pit at roughly the present observed depth. Approximately 30 yd³ of used roofing gravel and 1 yd³ of concrete rubble lie in piles dumped on the relatively level bottom of the borrow pit. The quantity of antifreeze and degreasers, as well as specific disposal locations within the pit, are unknown. No chemical inventory is available, but analysis of two surface soil samples taken in March 1988 revealed no evidence of contamination.

Waste dumped in either pit was probably hauled from the vicinity of the 1171 Building and dumped on the ground. Therefore, the most likely areas for waste disposal are in the vicinity of access points. For either pit, the southwest corner is the most likely spot. For the 1100-2 pit, dumping on either side of the railroad tracks is possible. Disposal would also be likely along the northeast side of the pit, because of proximity to Stevens Drive.

Liquid dumped on the ground at either site would generally tend to flow along the surface toward the center of the pit, and percolate into the soil quickly. During periods of heavy precipitation, water may tend to pond in the pits, picking up contaminants from the soil and carrying them downward to the groundwater.

Geologic conditions appear to be similar at each site. Well 3000-D-1 (Fig. 4-7) is located approximately 700 to 800 ft to the southeast. The log suggests that the upper 5 ft is sand, with gravel and sandy gravel present to a depth of approximately 85 ft (elevation approximately 320 ft above sea level), where brown silt or clay is encountered. This silt/clay layer in the Ringold Formation appears to be laterally extensive and probably acts as an aquiclude, defining the lower boundary of the unconfined aquifer. The groundwater level in the unconfined aquifer is at a depth of approximately 50 ft. The north Richland well field is located to the east-southeast, and groundwater movement may be in this general direction.

In the course of the site inspection activities at the 1100-EM-1 operable unit waste sites, an additional potential waste site was found. This site is a patch of oily, discolored soil in an elongated natural depression adjacent to the railroad tracks northwest of the 1171 Building. A grab sample of surface soils was taken from this site and found to contain

measurable concentrations of two phthalates, nine unknown acid-base neutral, and elevated TOC. Hence, this site has been designated as the "discolored-soil" site and will be investigated further. This site appears to be the location of a least one, and possibly several, incidents where drums of liquid material were dumped on the ground. The depression in which the spill is located would tend to collect and contain any surface water during periods of heavy precipitation. Given the relatively small volume of fluid involved, much of the contamination will likely remain in the upper few feet of soil, unless additional water is available to flush the contaminants through the soil column.

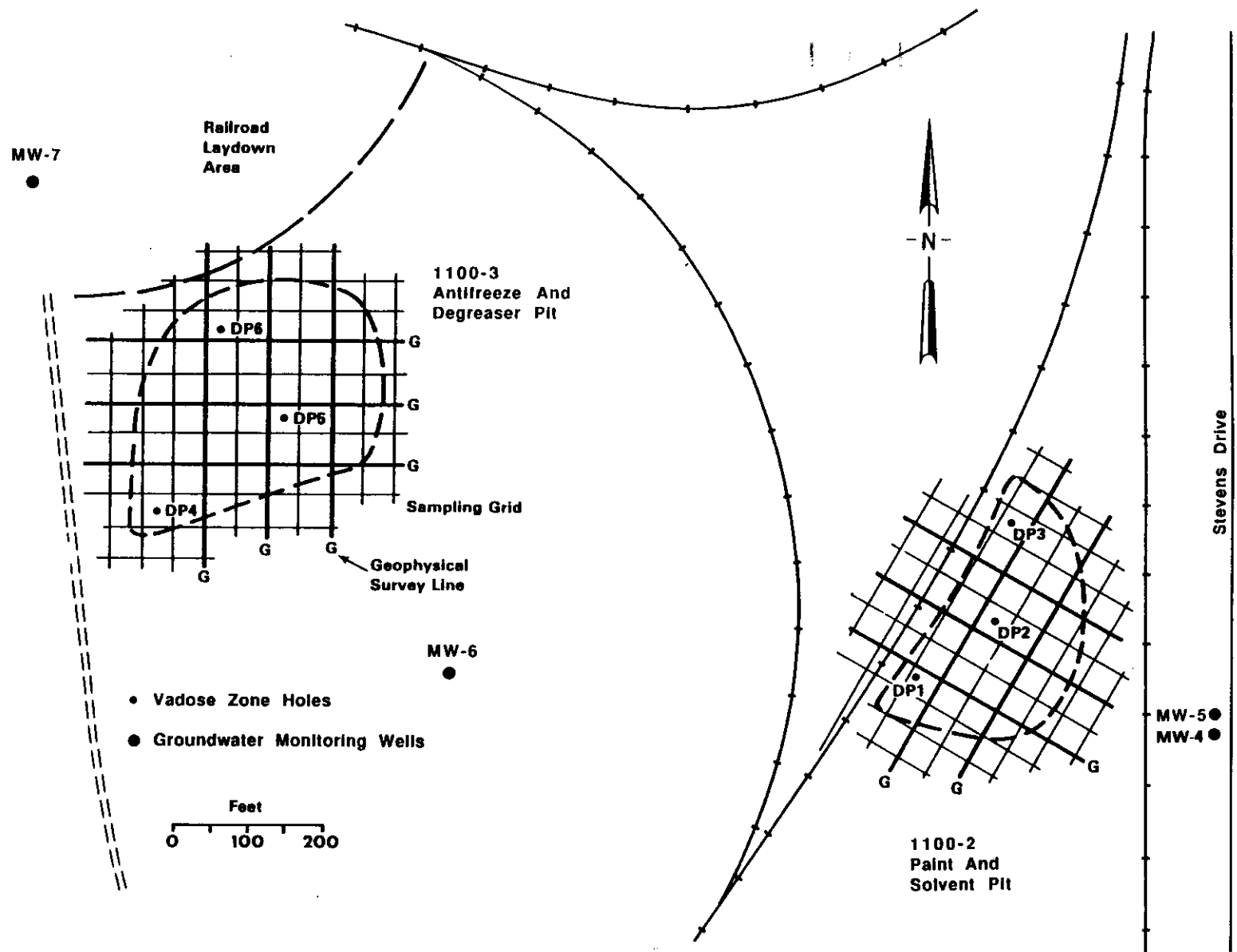
The only credible transport mechanism for contaminants at each of these sites is percolation through the soil column to the groundwater in the unconfined aquifer. The public water supply wells located in the north Richland well field (approximately 1/2 mi to the east-southeast) are the most credible receptors. Although local groundwater flow conditions are not known, the regional gradient is west to east. Therefore, it is assumed for the present that the direction of groundwater travel is toward the north Richland well field.

Figure 4-10 shows the location of various survey lines and sampling points proposed for the 1100-2 and 1100-3 sites. Although no radioactive material is known to have been disposed of at either pit, a radiological survey will be conducted using vehicle-mounted detectors. Any areas of surface contamination will be marked.

At both of these sites a sampling grid with a 40-ft spacing will be established. The 40-ft grid spacing is based on approximate depth to the water table, taking into account the geometry and overall size of each pit. At 1100-2, the grid will be oriented parallel to the railroad tracks. At 1100-3, the grid will be established in a north-south orientation. After the sampling grids are established, maps will be prepared and each site will be carefully inspected by geologists and biologists. Geologic features, type and condition of vegetation, evidence of small mammals, soil discoloration, and other pertinent features will be noted and located in relation to the sampling grid.

Geophysical surveys will be conducted along grid lines. The geophysical surveys will consist of ground-penetrating radar, metal detection, and electromagnetic (conductivity) measurements. Geophysical surveys may extend beyond the boundaries of each site as necessary to delineate anomalies. The purpose of these techniques is to determine the depth of fill at the site, to locate original boundaries of the excavations, to detect the presence of buried objects, and to detect anomalies that may be associated with the presence of contaminants.

After the geophysical surveys are completed, a soil-gas survey will be conducted, with samples taken at each node of the sampling grid. The purpose of the soil-gas survey is to detect and identify any organic vapors associated with the presence of volatile organic compounds in the soil or groundwater. The soil-gas survey may be extended beyond the boundaries of



28806.53.4

Figure 4-10. Vadose Zone Groundwater Sampling Plan for the Antifreeze and Degreaser Pit and the Paint and Solvent Pit.

each site as necessary to define the margins of any vapor plumes. Additional soil-gas measurements may be made at intermediate points to "fill in" as required.

After the geophysical and soil-gas surveys are completed (Phase 1A), the data will be evaluated, and Phase 1B sampling locations will be finalized.

Near-surface soil samples will be obtained from approximately 20 percent of the grid nodes in each site. Sampling nodes will be chosen by random selection. These samples will be obtained using an open-flight auger rig capable of drilling to a depth of 10 ft. Physical characteristics such as soil type, grain size distribution, and color will be noted in the field. The sand/silt/clay fraction of these soil samples will be analyzed for contaminants in accordance with test procedures identified in Table 4-8. Compounds of interest will include metals (by inductively coupled plasma), semivolatile organics, pesticides, PCBs, herbicides, and dioxins. Approximately 24 near-surface soil samples will be obtained from 1100-2, and approximately 36 near-surface soil samples will be obtained from 1100-3.

Three vadose-zone holes are proposed for each of the sites. These holes will be drilled using a hollow-stem auger. Samples will be obtained continuously from 0 to 20 ft deep, and at 5-ft intervals from 20 ft to total depth. Additional samples will be taken at any change in lithology. All holes will extend to the saturated zone. The preliminary locations of the holes were chosen on the basis of the conceptual models for each site. Final locations will be dependent on the results of the geophysical and soil-gas surveys. Additional holes may be added if the geophysical and soil-gas data indicate a higher degree of complexity than expected. The vadose zone holes will be completed as piezometers using a fiberglass pipe and a slotted plastic or fiberglass well screen.

Physical analyses of samples will also be conducted to provide data to support preliminary identification of remedial alternatives. These will include particle size, moisture content, bulk density, water retention, hydraulic conductivity and diffusivity, and cation exchange capacity. Specific test procedures are indicated on Table 4-10.

Four groundwater-monitoring wells will be installed in the vicinity of these two waste sites. The purpose of these wells is hydrogeologic characterization of the unconfined aquifer and detection of any contaminants that may be present. Two wells, MW-4 and MW-5, will be located in the assumed downgradient direction from both pits. Well MW-4 will be completed with a screened interval in the upper part of the unconfined aquifer, and well MW-5 will be completed with a screened interval in the lower part of the aquifer. Well MW-6 will be located upgradient of 1100-2 and downgradient of 1100-3. It will be completed in the upper part of the unconfined aquifer. Well MW-7 will be located upgradient of 1100-3 and will also be completed in the upper part of the aquifer. Well MW-6 will be drilled to the basalt to investigate hydrogeologic conditions. The wells will be located in such a way that water-level measurements in wells MW-4, MW-6, and MW-7 can be used to determine the general groundwater flow direction and gradient in the vicinity of the disposal pits. Water-level measurements will also be available from well 1199-S41-13C (3000-D-1), and from piezometers installed

in the vadose zone holes. Samples will be collected and logged in accordance with Westinghouse Hanford geologic logging procedures to characterize the hydrogeologic units in the vicinity of the disposal pits. Samples from well MW-7 will also serve as the background vadose zone samples. Additional wells will be considered after the initial phase of the RI is completed.

The discolored-soil site is assumed to be an area of surficial contamination resulting from surface disposal of the contents of one or more drums. The size of the discolored area suggests that a relatively small quantity of waste was involved and that significant percolation to the groundwater is not likely. The site will initially be investigated by means of hand-sampling tools. A sampling grid will be established with a 10-ft spacing. Samples will be obtained to a maximum depth of 5 ft, with a minimum of 10 randomly distributed sampling points. Of these, eight will be located toward the northeastern 25 percent of the depression where the discoloration exists, and the remaining two will be located toward the southwestern end. These samples will be analyzed for the full range of contaminants listed in the target compound list using analytical techniques identified in Table 4-8. If evidence of contamination is found, it will be necessary to obtain deeper samples by drilling one or more vadose zone holes.

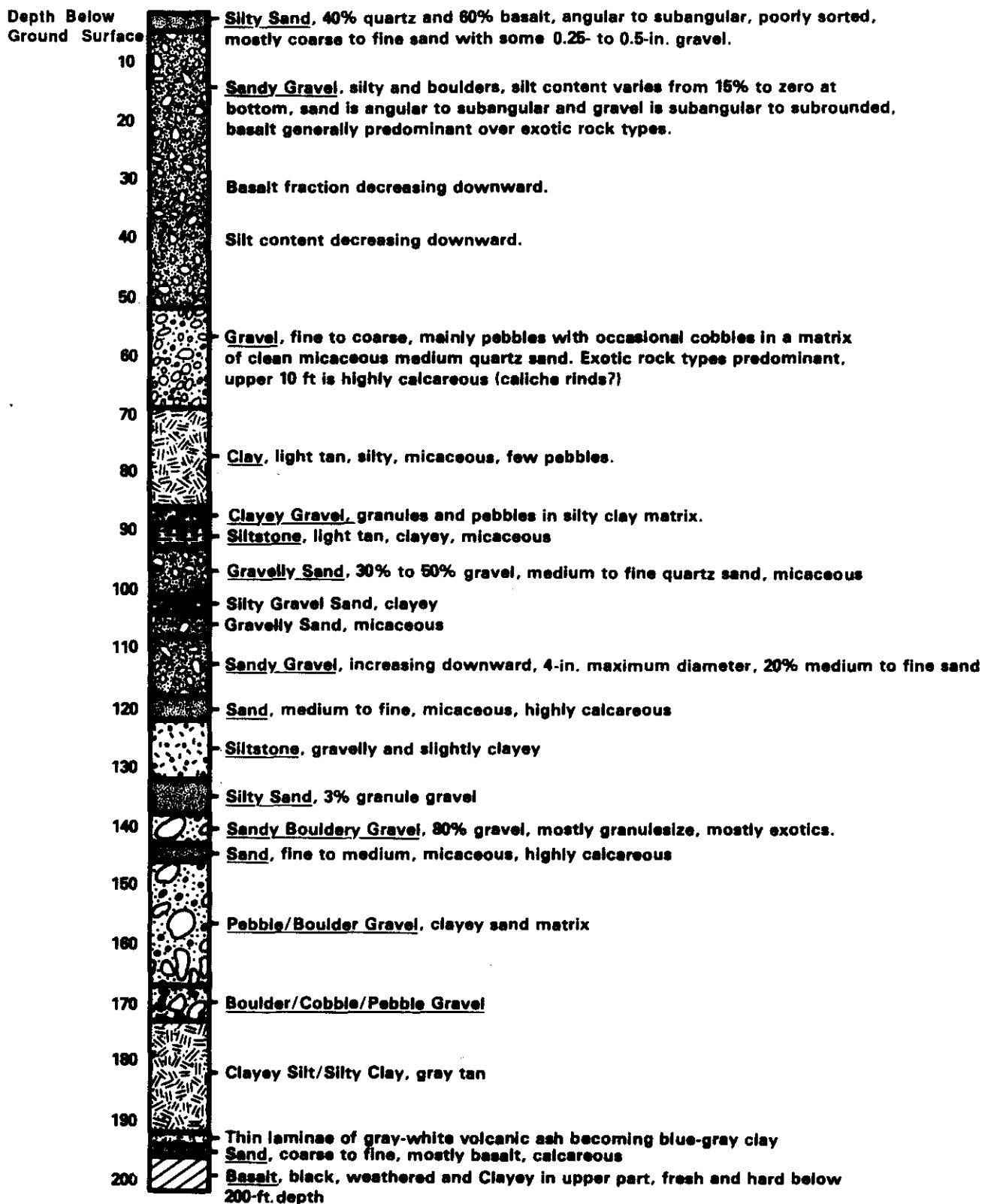
4.4.1.6 Horn Rapids Landfill. The Horn Rapids landfill was operated as a solid-waste landfill from approximately 1950 to 1970. The site is reported to have received indeterminate quantities of hazardous chemicals (possibly in drums), tires, asbestos materials, construction debris, and scrap lumber. Evidence also exists of liquid disposal; probably sewage sludge and/or fly ash. It was apparently used by a variety of contractors, and unauthorized dumping by both onsite and offsite parties was reportedly a continuing problem. Two larger north-south trenches in the southwest quadrant of the site may have received drums of carbon tetrachloride and possibly hazardous materials. The wastes were dumped from trucks into trenches, covered with dirt, and probably compacted to some degree by equipment operation.

Hanford Site personnel involved in operation of the landfill noted that standing water was frequently observed in the burial trenches, and that there were "springs" in the bottoms of the trenches. This indicates that wastes may be in, or very close to, the groundwater. This is consistent with the estimated depth to the water table and the estimated depth of the trenches (see Fig. 4-6). No liners or other barriers or covers were used, and no effort was made to divert water from the trenches.

Figure 4-11 shows the driller's log for a well drilled approximately 1 mi north of the Horn Rapids landfill. The driller's log provides a general indication of the geologic conditions likely to be encountered.

The primary transport mechanism of waste is infiltration or vapor-phase transport to the groundwater. Where wastes are in contact with the groundwater, contaminants may leach directly to groundwater. The groundwater flow direction in the vicinity of the Horn Rapids landfill is thought to be from west to east. Available water table data indicate easterly or northeasterly groundwater flow; however, perturbations to the water table from the operations in the 300 and 3000 Areas and possibly at Advanced Nuclear Fuels Corporation are likely.

Ground Surface
Level, 389 ft Above
Mean Sea Level



28009.63.9

Figure 4-11. Driller's Log for Well 10/28-10G1.

While no radioactive material is known to have been disposed of in the Horn Rapids landfill, a radiological survey will be conducted using vehicle-mounted detectors to ensure that radioactive contamination is not present at the ground surface. Any areas of surface contamination will be identified as radiation zones and decontaminated per Westinghouse Hanford procedures, as appropriate, prior to conduct of subsequent work in those zones.

Following the radiological survey, a sampling grid with a 100-ft spacing will be surveyed. The purpose of the grid is to establish well-located points for conduct of the soil-gas sampling and geophysical sampling. Additional intermediate grid points will be established as necessary for additional investigative work. The use of a closer spacing for the initial Phase 1A survey techniques over the entire area of the Horn Rapids landfill was rejected because of the size of the area to be investigated. The 100-ft spacing of the grid was chosen to minimize sampling points because transport of volatile wastes since last use of the landfill is expected to have spread contaminants over relatively large distances. Also, disposal areas are generally known; in these areas, supplemental grid lines can be added as necessary to provide more complete coverage. The spacing is also judged to be adequate for location of features identified by geologists and biologists and to provide adequate coverage by geophysical methods, supplemented by additional lines in known or suspected disposal areas. Detection of anomalies will result in utilization of finer sampling grids to further define the anomalous features.

After the sampling grid is established, maps will be prepared and the site will be carefully inspected by geologists and biologists. Geologic features, type and condition of vegetation, evidence of small mammals, soil discoloration, and other pertinent features will be noted and located in relation to the sampling grid.

At a minimum, ground-penetrating radar, metal detection, and electromagnetic measurements will be made along grid lines at the landfill. Surveys will be made along supplemental grid lines as appropriate to provide better coverage in areas of known or suspected waste disposal. The data from these surveys will be used to determine the amount of fill over the site, to detect buried objects, to better define the boundaries of the landfill, and to delineate individual burial trenches.

Following the geophysical surveys, a soil-gas survey will be conducted on the nodes of the sampling grid. The soil-gas data will be used to detect and identify organic vapors associated with volatile organic compounds in the soil or groundwater. Carbon tetrachloride in soil-gas will be of particular interest since barrels of this compound are reported to have been buried in the Horn Rapids landfill. If data warrant, a fine grid of 20-ft nodes may be taped off from the 100-ft surveyed nodes to provide greater spatial detail in the soil-gas analyses.

Phase 1B will consist primarily of drilling and sampling vadose zone boreholes within the landfill and groundwater monitoring and testing wells around the perimeter of the landfill. Additional near-surface soil samples will be obtained using hand-sampling methods or open flight auger rigs. The purpose of the vadose zone boreholes within the landfill is to define types of contaminants at or near their sources. On the other hand, the groundwater

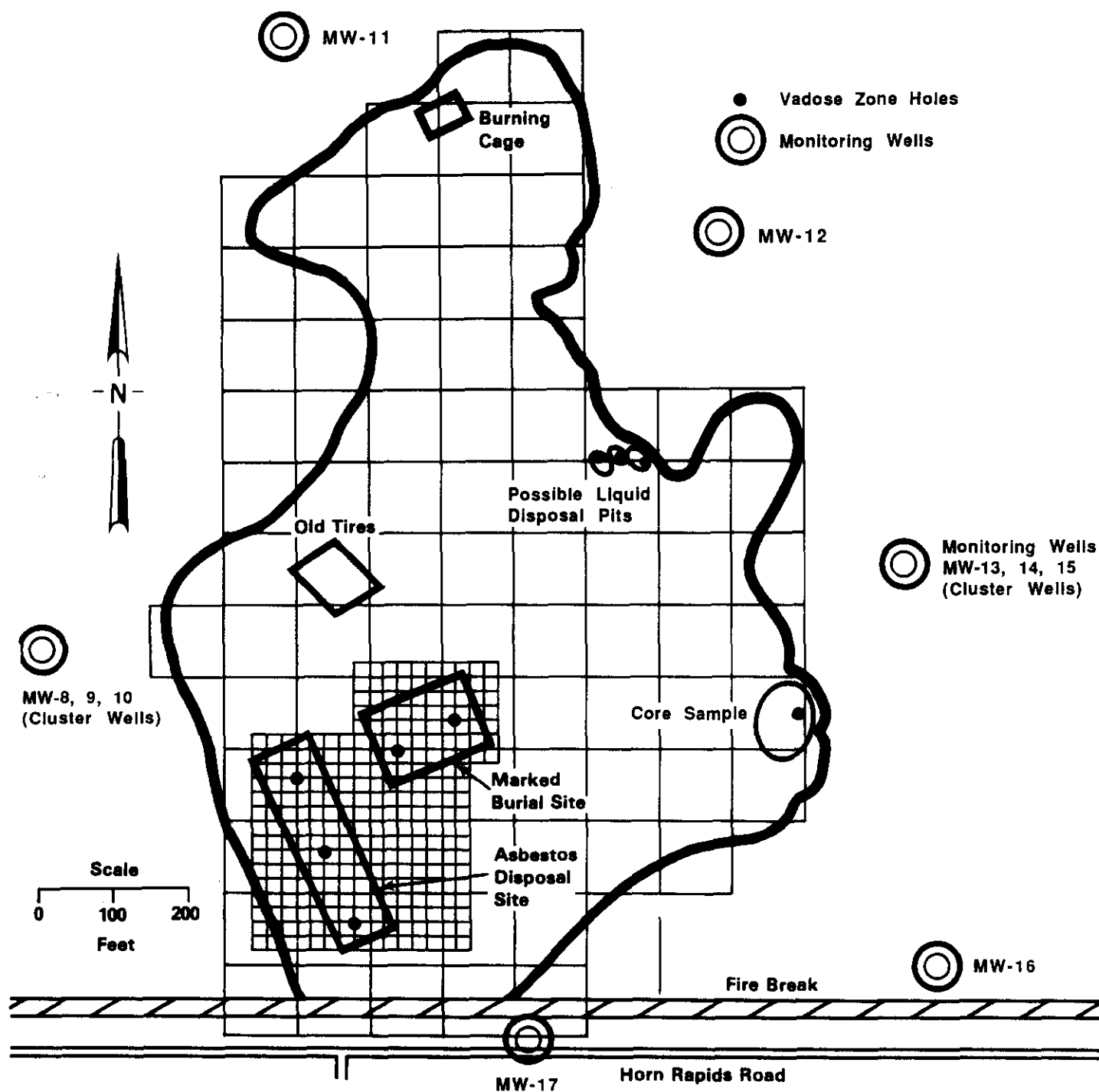
monitoring boreholes serve to detect contaminants that may have actually entered the groundwater and to define the groundwater flow directions and hydrologic properties.

Near-surface soil samples will be taken at random at approximately 20 percent of the grid nodes, with additional near-surface samples in areas of interest identified by the geologic or biological inspection of the area. These will be taken as composite samples from the upper 5 to 10 ft of soil. If possible, hand-sampling methods will be used; however, it is anticipated that a powered open-flight auger rig may be needed due to the high proportion of gravel and boulders in the soil.

Preliminary sampling locations for the vadose zone holes and groundwater monitoring wells are shown in Figure 4-12. After the Phase 1A geophysical and soil-gas surveys are completed, the data will be evaluated, and the locations of near-surface soil samples, vadose zone holes, and groundwater monitoring wells will be finalized. At a minimum, all proposed sampling locations within known or suspected burial areas will be screened with a portable magnetometer. In the event that drums or other forms of waste containers are detected by geophysical surveys, sampling points will be relocated to avoid penetrating these objects. It is anticipated that any buried waste containers will have to be exhumed for sampling of contents and possible removal. The specific approach to be used will be dependent on the circumstances of burial and the geologic conditions.

Based on existing knowledge of the landfill, nine vadose zone holes are tentatively proposed at four separate locations in the landfill. A minimum of three additional vadose-zone boreholes are planned for unexplored or randomly chosen locations contingent on Phase 1A results. The four locations for initial vadose-zone sampling were chosen because of visual evidence that contamination may be concentrated at these locations; however, other areas of contamination may not be so obvious. Therefore, the final locations of vadose-zone holes and monitoring wells to be drilled in Phase 1B will be determined only after careful examination of Phase 1A data. Preliminary identification of specific borehole locations described below was based on reasonable spatial coverage of each known or suspected disposal area that could serve as a source of specific contaminants.

The first location is a landfill cell marked as an asbestos disposal site, located in the southwest portion of the landfill. Three holes are proposed along the axis of the cell, with one in the center and one at about 80 ft from each end of the cell. Each of the three boreholes will extend to at least 10 ft below visual evidence of waste disposal, or to the saturated zone, whichever is greater. This criterion for depth will probably result in boreholes that are approximately 40 to 50 ft in depth. Samples will be taken at the surface, 2 ft and 5 ft below the surface, and every subsequent 5 ft, or at changes in lithology. Selected holes will be completed as piezometers by installing a slotted pipe or well screen at or below the water level. The locations of these boreholes were chosen so that samples from different regions of the trench would be obtained. There is a strong possibility that drums were buried in this trench. Therefore, geophysical data must be used in siting final hole locations to avoid penetrating any drums that may be present.



Note: Locations Shown Are Approximate

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Figure 4-12. Horn Rapids Landfill Preliminary Sampling Locations.

Chemical analyses of soil samples will be performed using methods listed in Table 4-8. Because of the uncertain knowledge of waste disposal, the initial analytical program will address all compounds on the target compound list (Table 4-9). In addition, samples will be examined for the presence of asbestos. Geologic logs will be prepared in the field and physical properties of soil samples will be determined in accordance with procedures listed in Table 4-10.

The second location in the landfill to be sampled is an area marked with two signs indicating "Burial Site" (Fig. 4-12). Two vadose-zone holes are proposed along the apparent axis of this area, each about 100 ft from the suspected ends of the burial site. These holes will be drilled to the saturated zone, or to at least 10 ft below the last evidence of disturbance or waste disposal, and water-level measurements will be taken upon completion. Similar precautions to those noted above must be taken to avoid drilling into drums. Analytical parameters will be the same as for the three boreholes in the first area, including analysis for asbestos.

The other locations where vadose-zone holes are proposed are at two areas of the landfill where visual evidence suggests that liquids and sludge were disposed of at the landfill (Fig. 4-12). The first area is to the north and east of the burial site, along the eastern boundary of the landfill. There are two distinct pits, and one area between the two pits that may represent a backfilled pit. Three vadose-zone holes are proposed for this area, with one hole in each of the pits and one in the area between. In the westernmost pit, the hole will be located at the low point in the pit, because liquid waste disposed of in the pit is most likely to be concentrated at this point. In the easternmost pit, there is an area that contains a mound of broken glass, with rubber laboratory stoppers scattered around and in the mound. Based on discussions with personnel who have worked at the Hanford Site for many years, this glass is probably related to disposal of unwanted and potentially explosive compounds (e.g., picric acid, ethers, etc.). The proposed hole within this pit is at the location of the glass mound. A third hole will be drilled in the center of the area, where a backfilled pit is suspected.

The other area where liquid disposal is suspected is also along the eastern boundary of the landfill, about 1,000 ft south of the liquid disposal pits discussed above. The sludge in this area is not located in a pit, but in a low area of the landfill. The proposed vadose-zone hole in this area is at the lowest point, where any contaminants should be most concentrated. This low area is essentially along the eastern boundary of the landfill.

Samples from each hole in both of the liquid disposal areas will be taken continuously from the surface to a depth of 20 ft, and at 5-ft depth intervals or at changes of lithology from 20 ft down to the saturated zone. Chemical analyses will be performed on the 0-, 2-, 5-, and 10-ft depths, and at subsequent 10-ft samples down to and including the saturated zone. These analyses will address the target compound list compounds. Because the surface deposits in the pits and in the low area to the south may be sewage sludge, coliform bacteria counts will be added to the list of analytes for these samples.

Besides the vadose-zone holes discussed above, a minimum of three additional holes will be drilled in unexplored locations within the landfill. Unless the data from Phase 1A suggest locations for these boreholes, their locations within unexplored areas will be selected on a random basis. The main purpose of these boreholes is to detect any contamination from unknown sources in the landfill. Selected vadose zone holes will be completed as piezometers by installing slotted pipe.

Ten groundwater monitoring wells are proposed at six locations surrounding the Horn Rapids landfill to investigate the hydrologic properties of the unconfined aquifer and to detect groundwater contamination from waste disposal at the landfill (Fig. 4-12). The spatial arrangement of the proposed wells is intended to provide two upgradient and four downgradient wells under a range of easterly to northeasterly flow directions. Geologic samples will be taken at 5-ft depth intervals and at changes in lithology during the drilling operations, to support hydrogeologic characterization. These samples will be described and tests for specific hydrologic parameters will be performed per the data quality objectives. One of the upgradient wells and one downgradient well will be well clusters with three wells 25 to 50 ft apart completed in the upper, middle, and lower portions of the unconfined aquifer. The purpose of the cluster wells is to determine if contaminant levels are stratified in the aquifer, an observation that is particularly important for dense liquid contaminants such as carbon tetrachloride. All other monitoring wells will be completed in the upper portion of the aquifer.

After completion of aquifer tests, the monitoring wells will be sampled quarterly for 1 yr. At the end of the 1-yr period, data on contaminant concentrations will be evaluated and a determination will be made on the need for additional sampling. Depth to the water table will be measured on the same quarterly schedule as the groundwater sampling. The need for additional water table mapping will be evaluated after a 1-yr period.

4.4.1.7 Geochemical Analysis of Soil Samples. Laboratory testing of soil samples obtained during the RI may be used to determine contaminant release rates (waste solubility and desorption behavior), contaminant retardation properties of the vadose-zone sediments (waste leachate/sediment interactions), and contaminant/groundwater interactions (aquifer geochemical interactions). These tests will be designed to evaluate contaminant mobility at each of the major waste sites located in the 1100-EM-1 operable unit.

Contaminant release-rate experiments may be performed on composite samples obtained from each of the waste sites. Soil samples containing hazardous substances will be composited for site-specific leaching studies. Wastes will be leached in a column experiment to assess the mobility of hazardous substances found at each site.

Leachates generated from the waste-leaching experiments or other suitable means may be passed through composite sediment columns representative of each stratigraphic or lithologic unit. These studies will be performed to evaluate the geochemical behavior of hazardous substances as they migrate through the vadose zone from the near-surface environment to the groundwater.

Groundwater from the "affected environment" beneath these waste sites may also be used in column studies with composite sediments from the upper portion of the unconfined aquifer. If no groundwater contamination exists beneath a site, these aquifer geochemical tests may be redesigned and/or eliminated depending on the extent of contamination. Together, these geochemical analyses provide base-case information for the no-action alternative and the water-flushing alternative.

4.4.1.8 Disposal of Sampling Media. Sampling media include all soils and groundwater brought to the surface while drilling, coring, excavating, pumping, or using other methods in an effort to collect samples or to conduct tests. All media not part of the sample will be controlled according to appropriate procedures (see Appendix C).

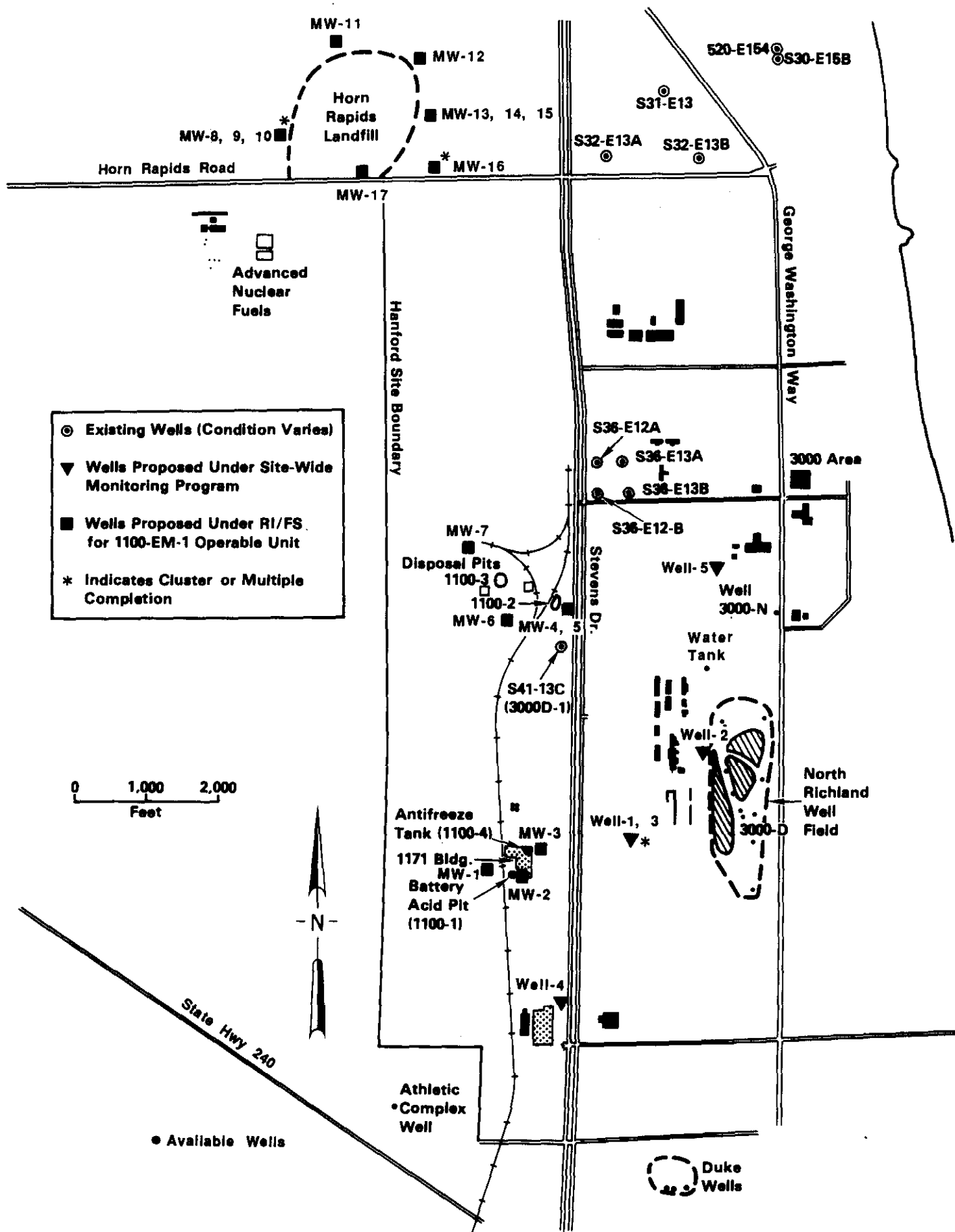
4.4.1.9 Additional Groundwater-Monitoring Wells. In addition to the groundwater-monitoring wells to be drilled at each waste site as part of the RI Phase 1B, five additional monitoring wells have recently been drilled in the 1100 Area to the west and north of the north Richland well field. These wells were drilled as part of the site-wide groundwater monitoring program and are not considered part of the RI/FS effort. Data should be available from these wells before the RI work is initiated. In addition, several other wells in the vicinity are available for sampling. Available data from these wells are included in Appendix B. Locations of all existing and proposed groundwater-monitoring wells are shown in Figure 4-13.

4.4.2 Atmospheric Characterization Program

The atmospheric component of the data collection program is divided into two major tasks. The first task involves characterization and monitoring of air quality, including collection of air samples in the ambient atmosphere upwind from the waste disposal site and samples in the potentially contaminated atmosphere downwind of the site. A comparison of the samples can be used to determine whether or not contaminants are being emitted to the atmosphere from the waste site in quantities that may have a significant environmental impact. The second task involves characterization of the meteorology of the site. This includes the monitoring of winds, atmospheric stability, and other parameters. These data are needed to estimate the atmospheric transport and diffusion of an effluent from a waste disposal site and the resulting ground-level air concentrations.

4.4.2.1 Air-Quality Monitoring. The air quality monitoring program will be designed to monitor air contaminants that may be associated with waste sites in the 1100 Area. Because there is some uncertainty as to the types and quantities of the various wastes at some of the sites in the 1100 Area, a broad spectrum of monitoring will be conducted. Specifically, the monitoring program will examine both volatile and semivolatile organic compounds, pesticides, PCBs, metals, and total suspended particulates.

The 1100 Area waste sites will be divided into three study areas: the Horn Rapids landfill, the central portion of the 1100 Area, and the area around the 1171 Building. Air monitoring in the central portion of the 1100 Area will focus on emissions from the paint and solvent pit, the antifreeze



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Figure 4-13. Locations of Existing and Proposed Groundwater Monitoring Wells.
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and degreaser pit, and the discolored-soil site. Monitoring near the 1171 Building sites will cover the battery acid pit.

4.4.2.1.1 Sampling Locations. Air quality monitoring at the three study areas will involve the collection of air samples upwind and downwind of the waste disposal sites. Upwind sampling will be conducted to determine ambient air quality independent of any influence from the waste sites. Downwind sampling will be conducted to determine the effects of atmospheric transport and diffusion on the air concentration of any pollutants emitted from the waste sites. Two downwind sampling locations will be selected to compensate for the normal meander in wind direction. Additional sampling for occupational safety purposes will be conducted at the waste site (see Section 6.0) to determine the concentrations of pollutants to which site workers may be subjected.

Specific locations for sampling will be determined based on the prevailing wind direction for the time of year that the sampling will be conducted, site activities, sources of potential contamination, and site security. Monitoring will be conducted during periods of light to moderate wind speeds, when wind directions are fairly constant. Because of the orientation of the prevailing winds in the 1100 Area, the upwind samplers are anticipated to be located about 310 ft southwest of the waste disposal sites, and the downwind samplers will be located a similar distance to the northeast of the disposal site.

Sampling will be conducted before, during, and after site analysis activities. Air quality sampling will be conducted before site investigation activities to determine if pollutants are being routinely emitted to the atmosphere from prior disturbance by sampling activities at the disposal site. Sampling will be conducted during site investigation activities to determine if subsurface sampling activities are providing a pathway for the emission of pollutants to the atmosphere. Finally, air quality sampling will be conducted after all subsurface and other surface sampling activities are completed to determine if air pollutant concentrations have returned to previous levels.

Sampling at the Horn Rapids landfill will be complicated by the presence of the Advanced Nuclear Fuels Corporation facility about 0.6 mi southwest of the disposal site. Sampling will be conducted at this site only when the nuclear fuels facility is not noticeably emitting pollutants to the atmosphere, or when these emissions are at a minimum. Additional sampling locations in the Horn Rapids landfill area may be required to characterize any influence from the nuclear facility will be sought to minimize any potential interference with our monitoring from activities at the nuclear fuels facility.

4.4.2.1.2 Sampling Equipment and Procedures. Three types of samples will be taken at each monitoring location. The first air sample will be for volatile organic compounds and will use one of the commercially available collection methods (e.g., carbon molecular sieve). The second sample will be for semivolatile organic compounds, pesticides, and PCBs. This will also be collected using a commercially available collection method (e.g., polyurethane foam). The third samples will be for metals and total suspended

particulates. This sample will be collected using high-volume filter sampling techniques.

Each air and particulate sample will be collected over a 4- to 12-h period, with the exact time depending on activities at the site and meteorological conditions. Unchanging wind directions (with allowances for the normal meander in wind direction) are required for sampling purposes. Sampling periods will be shortened if there is a significant change in wind direction. Procedures for operating, maintaining, and calibrating the sampling equipment will be according to the individual manufacturer's guidelines and applicable Hanford Site quality assurance procedures.

4.4.2.1.3 Analytical Methods and Data Processing. All samples will be collected, prepared for laboratory analysis, and analyzed using EPA-approved methods. The laboratory analysis for volatile organic compounds will be conducted using gas chromatography/mass spectrometry. The air sample to be analyzed for semivolatile organic compounds, pesticides, and PCBs will be split in half. The filter samples to be analyzed for metals and total suspended particulates will be processed using EPA guidelines.

4.4.2.2 Meteorological Monitoring Program

4.4.2.2.1 Sampling Locations. A comprehensive program of meteorological monitoring is in place at the Hanford Site. Meteorological data are collected at the Hanford Meteorological Station and at 24 additional automated monitoring stations located throughout the Hanford Site region (onsite and offsite). Two of the automated meteorological monitoring stations are located in close proximity to the 1100 Area. A 200-ft meteorological tower (the 300 Area station) is located less than 1 mi north-northeast of the Horn Rapids landfill and approximately 3 mi north of the 1171 Building in the 1100 Area. A second automated monitoring station is located at the top of the Richland Airport control tower, about 2 mi to the south-southwest of the 1171 Building. Continuous meteorological monitoring has been conducted at these two locations since early 1982.

Data from the Hanford Site meteorological monitoring network will be used to characterize the climatological conditions at the 1100 Area waste sites. Wind and air temperature data collected at the 300 Area station should be representative of meteorological conditions at the Horn Rapids landfill. There is uncertainty as to how representative the 300 Area and Richland Airport monitoring stations are of conditions in the central and southern portions of the 1100 Area. To determine the degree of representativeness, a short-term program of meteorological monitoring needs to be set up for the 1100 Area.

To study the meteorology of the central and southern portions of the 1100 Area, a 30-ft instrumented tower is proposed to be set up at a west-central location in the 1100 Area. This location will be selected so as to minimize the effects of buildings, trees, and other structures on local wind flow patterns. Data from the site will be compared with data from the 300 Area and Richland Airport monitoring sites. If one of these two meteorological monitoring stations is found to be representative of conditions at the disposal sites, monitoring at this location can be discontinued and data from the representative station will be used in future

analysis work. If neither of the sites provides a satisfactory representation of the meteorology at the disposal site, the short-term meteorological monitoring at the site will be continued for as long as data are required.

Because of the number and the size of the building in the southern portion of the 1100 Area, these structures can have a significant impact on local winds and temperatures. For this reason, additional meteorological monitoring may be required near the 1171 Building to adequately characterize the impact of the building on the near-surface winds and air temperatures experienced at the nearby waste sites.

4.4.2.2 Sampling Equipment and Procedure. Short-term meteorological monitoring in the west-central portion of the 1100 Area will involve the deployment of a meteorological tower at least 30 ft high. Measurements of wind direction, speed, and air temperature will be made at approximately 30 ft and 6 ft above ground level. Data will be automatically recorded and transmitted to the Hanford Meteorological Station. The monitoring station will be calibrated using the same standards employed for the stations in the Hanford Site meteorology monitoring network. The period of operation of the station will depend on the representativeness of data collected at the 300 Area and Richland Airport monitoring stations. Monitoring may encompass the entire period of air quality monitoring and may be continued beyond the end of the project as part of routine Hanford Site meteorological monitoring.

The monitoring of meteorological parameters near the 1171 Building will be conducted during operations and air quality sampling at the site. The instrumentation used at this site will be comparable to the instrumentation to be employed at the west-central 1100 Area monitoring site.

4.4.3 Biota

Biotic sampling is not planned for the battery acid pit (1100-1), the antifreeze tank site (1100-4) or the radiation contamination site (1100-5). These sites are generally devoid of vegetation and do not provide a habitat conducive to small animals.

The disposal pits (1100-2 and 1100-3) and the discolored-soil site are inhabited by vegetation such as cheatgrass, tumbleweed, and rabbitbrush, as is typical for disturbed areas at the Hanford Site. There is also evidence of burrowing animals (pocket mice and badgers) at these sites. These animals are prolific burrowers. Pocket mice are the primary prey species for the badgers.

The Horn Rapids landfill exists in a similar ecologic setting. However, because of its size, it can be expected to harbor a greater diversity of animal and plant species.

A visual reconnaissance effort will be conducted at these sites by qualified personnel to locate and evaluate any evidence of uptake of toxic substances by plants or animal. Any evidence of weakened, necrotic, or chlorotic plants will be documented by species. Observations would also be made of evidence of small mammals and bird species and animal-burrowing

activities. Where possible, at least two soil samples from pocket mouse or badger mounds will be collected at each site and analyzed as discussed in Section 4.4.1. A threatened and endangered species survey will also be conducted as part of the biotic reconnaissance effort. For comparison purposes, at least one control site (preferably similarly disturbed) located nearby (within approximately 2 mi) would also be examined in the same way.

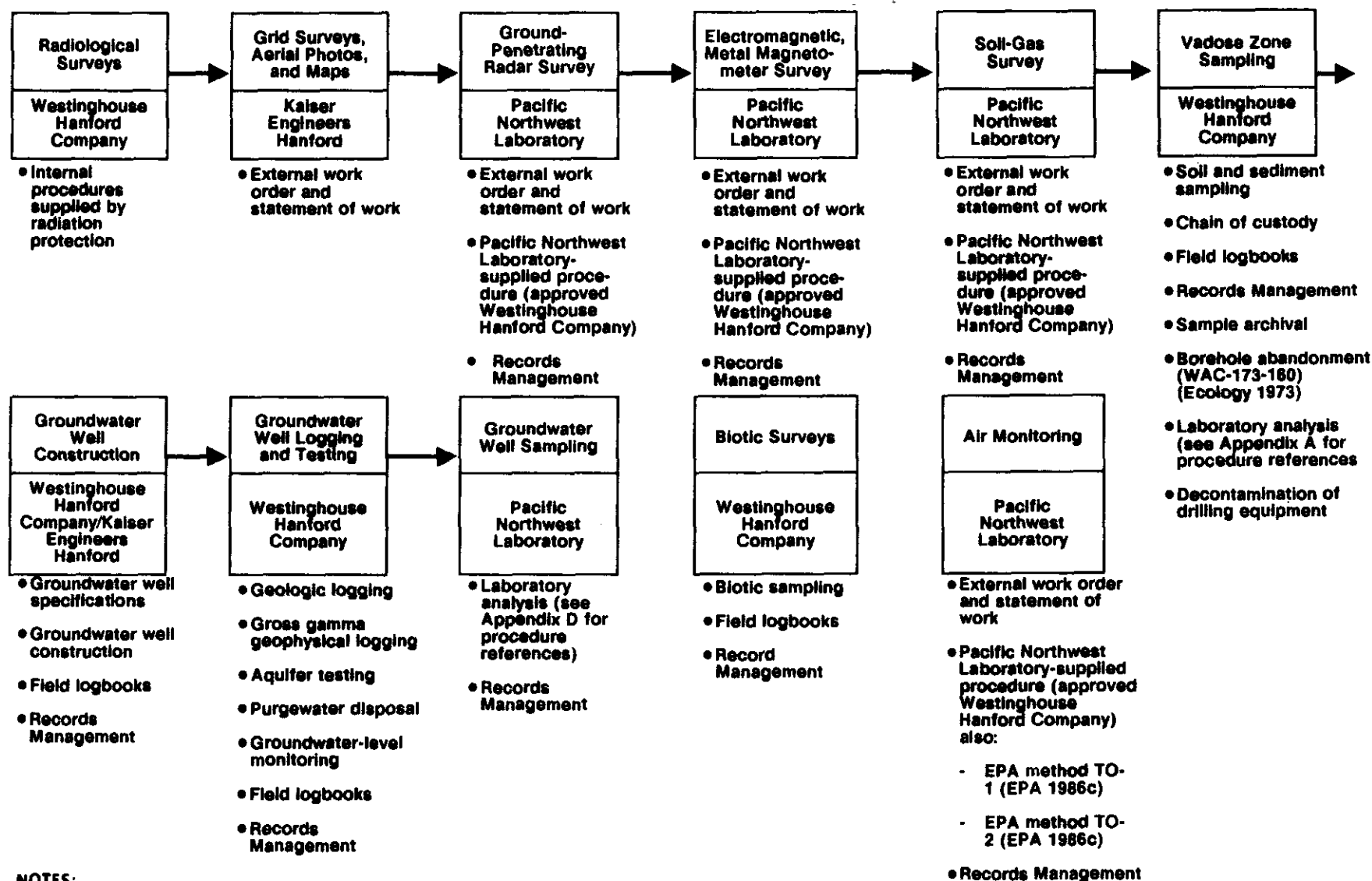
5.0 QUALITY ASSURANCE PLAN

5.1 INTRODUCTION

The basic objective of the QA plan is to ensure that data, findings, and results are sufficiently accurate and reliable to support decisions associated with site evaluation, risk assessment, and evaluation and selection of remedial alternatives. In addition, activities will be based on approved plans and procedures and adherence to plans and procedures must be enforced and documented. Where necessary, changes to approved procedures and plans will be made in a controlled manner, and adequate documentation will be maintained. Traceability will be established and maintained between results and findings used in making decisions and the original measurements and/or samples.

To achieve the basic QA objective stated above, internal QA documents (Figure 5-1) will be used that address the applicability of nuclear QA requirements (ANSI/ASME NQA-1 1986) to RI/FS work. These documents, in conjunction with the procedures listed in Table 5-1 and Appendix C, provide the basis for a QA program that satisfies DOE-RL Order 5700.1A (1983) and EPA and internal Westinghouse Hanford QA requirements. Another document will discuss the 18 quality elements of ANSI/ASME (1986) and relate them to EPA QA guidance document requirements. The document will address such areas as the following:

- Management policies
- Organization charts and charters
- Management requirements and procedures
- Document clearance and information release
- Records management
- Quality assurance
- Operational health physics
- Standard engineering practices
- Radioactive solid waste packaging, storage, and disposal requirements
- Publication style
- Procurement.



NOTES:

- See Appendix C for details regarding procedures in process (procedures will be cleared for public release).
- EPA = U.S. Environmental Protection Agency.
- WAC = Washington Administrative Code.

PST89-3024-3

Figure 5-1. Matrix of Specific Procedures.

5.2 PROJECT QUALITY ASSURANCE ORGANIZATION AND RESPONSIBILITY

Overall project organization and responsibility are discussed in Section 3.0. An organization chart is provided in Figure 3-1. Work associated with the RI/FS will be carried out under the direction of Westinghouse Hanford acting as unit manager for the DOE. In this capacity, Westinghouse Hanford is responsible for planning, implementing, and maintaining a QA program in accordance with DOE-RL Order 5700.1A (DOE-RL 1983). The purpose of this section is to define the responsibilities of the technical lead, the RI coordinator, the field team leaders, and the quality coordinator with regard to quality assurance.

Figures 3-3 through 3-8 illustrate the organizational structures used to carry out specific RI activities. The technical lead is the designated individual from Westinghouse Hanford responsible for the overall direction of the RI/FS work.

The RI coordinator is the designated individual from the Westinghouse Hanford Environmental Engineering Group who is responsible for coordinating RI activities and ensuring that all laboratory analysis activities are carried out in accordance with approved plans and procedures. The RI coordinator will also supervise data assessment and evaluation carried out by the appropriate RI technical resources.

The field team leaders are designated individuals from Westinghouse Hanford, PNL, or subcontractors who are responsible for a particular sampling or field investigation activity. The field team leader is responsible for ensuring that field investigation and sampling activities are carried out in accordance with approved plans and procedures. The field team leader will also maintain calibration and maintenance records for field equipment and will supervise collection, preparation, handling, storage, and custody of samples, including field quality control (QC) samples.

The quality coordinator will verify compliance with plans and procedures by conducting audits, surveillances, and inspections, and will verify that data assessment and evaluation have been completed and documented.

5.3 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT

The suitability of data to support important decisions associated with the RI/FS process can be stated in terms of the validity and reliability of the measurement and the degree of uncertainty associated with numeric values. Validity and reliability are established primarily through implementation of a QA program to ensure that all measurements are taken in accordance with approved plans and procedures and that adequate documentation is maintained to provide traceability and accountability. Uncertainty of measurement data is stated in terms of precision, accuracy, representativeness, completeness, and comparability parameters.

Specific objectives are discussed in Section 4.3.4 and stated in Table 4-3 as DQOs. Because relatively little site-specific data are available, the DQOs are stated in qualitative terms. More specifically, quantitative DQOs will be provided for subsequent phases of the RI work as specific contaminants are identified, site characteristics become better known, and remedial objectives become better defined.

5.3.1 Precision and Accuracy

Precision measures the reproducibility of measurements under a given set of conditions, while accuracy refers to the difference between the measurement and the true value. Specifically, precision is a quantitative measure of the variability of a group of measurements compared to their average (mean) value. Precision is generally stated in terms of the standard deviation. Accuracy is a quantitative measure of the closeness of an individual measurement or the mean of a set of measurements to the true value. Accuracy is generally stated in terms of percent recovery, based on analysis of measurements of a reference sample of known value. It is possible to have a set of measurements with high precision but low accuracy.

The overall precision and accuracy of a set of measurements is a function of both sampling and analytical factors. Sampling factors are typically unique for each site. They include the inherent variability of the measurement itself, the errors associated with the sampling process, and other factors such as field contamination and sample preservation, handling, and transportation. The degree of error associated with sampling factors is evaluated by analysis of field QC samples as discussed in Section 5.3.5.

Analytical factors are related to the performance of the laboratory. The degree of error associated with analytical factors can be estimated from evaluation of historical laboratory data, including analysis of laboratory quality control samples carried out in accordance with the laboratory QA plan. Quarterly reports, which include precision and accuracy data, are available from the laboratory (U.S. Testing). In addition, quantitative statements of precision and accuracy will be requested from the laboratory for analytes present in soil and water samples at concentrations above detection levels.

5.3.2 Representativeness

Representativeness expresses the degree to which parameters, based on evaluation of the sample data, correctly represent the characteristics of the population from which the samples were taken. Representativeness is a qualitative parameter that is obtained by proper planning of the sampling program, particularly with regard to selection of sampling sites and sample collection methods.

5.3.3 Completeness

Completeness is defined as the proportion of measurements that are judged to be valid in relation to the number of measurements that are necessary (or should have been made) to satisfy a DQO.

The final determination as to whether or not sufficient valid data have been collected can only be made after the data are evaluated with regard to their intended use, taking into account an improved understanding of site conditions that results from the data collection program.

For example, in the initial phases of the RI/FS process where the goal is identification of any contaminants on the site, relatively little data may be sufficient to support the required decision as to whether or not remediation of a particular contaminant is required. However, considerably more data may be required to select an appropriate remedial action.

5.3.4 Comparability

Comparability is a qualitative parameter that expresses the degree to which one set of measurement data can be compared to a similar set. The goal of comparability is achieved through the conformance to approved procedures for both sample collection and laboratory analysis. Analytical results must be reported in appropriate units to facilitate comparison. The degree of comparability between data sets also depends to some extent on the accuracy, precision, and representativeness of the measurements.

5.3.5 Field Quality Control Sampling

This section presents a general discussion of field QC samples. Specific recommendations regarding each sampling method and environmental medium are discussed in Section 5.3.6.

Five general categories of field QC samples can be collected to support data evaluation. The applicability and frequency of these samples depend on the medium. Analysis of these samples will support evaluation of accuracy, precision, and representativeness.

- Blanks are samples containing no contamination, used to check for the introduction of contamination during sample collection and/or handling. These include: field blanks, which are collected by passing contaminant-free water (or other media) through the field sampling equipment; and trip blanks, which are prepared in the laboratory to accompany the sample containers to and from the sites. In some cases, background samples may serve as field blanks. Typically, at least one field blank is prepared for every 20 samples, and one trip blank is prepared for each day or episode of sampling.

- Replicates or collocated samples are multiple samples of the same medium taken at the same location (or very close). Field replicates may be produced by splitting a sample in the field. Laboratory replicates are produced by splitting the sample after it has arrived at the laboratory. Field replicates or collocated samples are typically collected at least once for every 20 samples. The frequency of laboratory replicates is specified in the laboratory QA plan.
- Interlaboratory splits are replicate samples sent to different laboratories to independently assess the accuracy and precision of the laboratory data.
- Blind standards contain a known contaminant level. They are submitted to the laboratory as field samples to independently verify the degree of analytical bias.
- Matrix spikes are samples to which a known amount of the analyte has been added. When prepared in the field immediately after sample collection, field spikes provide a good assessment of matrix effects, as well as sampling, handling, and preservation error. However, the use of field matrix spikes is generally not recommended because of the high level of technical expertise required for their successful use and their sensitivity to environmental variables. Errors in preparing the spike may result in serious problems in interpretation of the sampling data. Therefore, field matrix spikes will not be prepared unless specifically noted. Matrix spikes may be prepared in an independent laboratory to assess laboratory performance and sensitivity to matrix effects.

The effects of analytical and sampling factors on precision can be determined by collecting and analyzing collocated or field replicate samples and then creating and analyzing laboratory replicates from field samples. The analytical results from the collocated or field replicate samples provide information on overall precision. Analytical precision is determined from the results of the laboratory replicates and from internal laboratory quality control samples. The sampling precision is then the difference between the overall precision and the analytical precision.

Sampling accuracy, which includes preservation and handling, can be evaluated by the use of field and trip blank samples. Analytical accuracy can be evaluated by the use of known and unknown QC samples (standards) and matrix spikes.

Field blanks will be prepared and analyzed to assess the potential for contamination from sampling equipment, which may affect the representativeness of the data. Analysis of collocated or field replicate samples also provides information on the representativeness of the data.

Field QA samples will be documented in the field logbooks and submitted to the laboratory in the same manner as other samples, with no specific

identification to differentiate them from other samples. The results of the field QA samples are used to assess the overall quality of the data obtained from the sampling and analysis program.

5.3.6 Media-Specific Field Quality Control Sampling

The following discussion identifies specific types and frequency of collection for field QC samples or measurements.

5.3.6.1 Geophysical Surveys. The field QC effort will consist of replicate measurements for every twentieth point for point survey methods (such as EM, soil resistivity, or metal detection). For line survey methods (such as ground-probing radar), duplicate or repeat surveys will be made at least once at each site. For geophysical logs, a repeat section (replicate) of at least 10 ft will be run at least once in each hole for each logging tool.

5.3.6.2 Soil-Gas Survey. Because the soil-gas survey is basically a laboratory procedure run in the field, the field QC samples serve a dual function of both field and laboratory performance assessment. Blanks will be run for every tenth sample, and a field replicate and standard will be run for every twentieth sample.

5.3.6.3 Air-Quality Sampling. A blank will be collected at each sampling site for volatiles and semivolatiles. No other field QC samples are deemed appropriate for air sampling in this phase.

5.3.6.4 Biota. If biotic sampling is implemented, one collocated sample will be collected for each shrub species. No other field QC samples are deemed appropriate in this phase.

5.3.6.5 Sediment and Soils. No field QC samples will be collected for physical properties in this phase of the RI. However, samples not tested will be archived for future evaluation where feasible. For chemical analyses, at least one field replicate will be collected for every 20 samples, with a minimum of one field replicate at each site. At least one interlaboratory split will be collected for the core 1100 Area and the Horn Rapids landfill. Background samples will serve as field and trip blanks.

5.3.6.6 Groundwater. At least one trip blank and one transfer blank will be prepared for each day of sampling. One field blank will be collected for each 20 samples, with at least one field blank for each episode of sampling. Field replicates and interlaboratory splits will be obtained from at least one well in the 1100 Area and one well in the Horn Rapids landfill for each episode of sampling. Assuming that all wells will be sampled at approximately the same time, one set of appropriate blind standards will be prepared for every round of sampling. Groundwater samples will generally not be archived, due to holding time restrictions.

5.4 PROCEDURES

Procedures applicable to each step of the initial RI work (Phases 1A and 1B) are indicated in Figure 5-1. Further discussion follows in the sections below.

5.4.1 Field Sampling Procedures

Field sampling and data collection procedures are listed in Appendix C. These procedures are presently being developed. As they are completed, approved, and cleared, they will be incorporated in a manual of environmental investigation and site characterization procedures. These procedures address the specific methodology for data collection during site characterization activities. Procedures required for field investigation activities that are not identified in Appendix C will be either written and approved as required or provided by the subcontractor or PNL to the technical lead for review and approval prior to initiation of the work.

5.4.2 Sample Custody

Chain-of-custody procedures will be observed for field samples. Other field measurements and sampling information will be noted on field data sheets and will be logged in controlled field logbooks. A chain-of-custody procedure is being developed as part of the environmental investigation and site characterization manual.

5.4.3 Analytical Methods and Procedures

Two laboratories on the Hanford Site have been identified as having the required expertise to provide Analytical Level III and IV laboratory services. These are U.S. Testing and the PNL Chemical Sciences Department Chemistry and Analysis Laboratory in the 325 Building. U.S. Testing currently provides support for nonradioactive and low-level RCRA monitoring at the Hanford Site, while the PNL Chemistry and Analysis Laboratory is equipped to handle high-level radioactive samples. Both laboratories can provide analyses in accordance with EPA-CLP protocols. Specific EPA methods for laboratory analysis are given in Table 4-8.

Because radioactive contamination is not anticipated in the 1100 Area, U.S. Testing will be used to provide analytical services. Appendix D contains the U.S. Testing statement of work, which specifies analytical procedures, sample sizes, and minimum detectable concentrations. An example of the U.S. Testing hazardous waste sample order form is also included in Appendix D.

The PNL laboratory QA program document was developed specifically following EPA guidance (EPA 1987d) to support Hanford Site CERCLA activities, whereas the U.S. Testing program document was developed to support

contractual requirements with the DOE. These requirements are defined in ASTM-C1009-83 (ASTM 1983) and ANSI/ASME NQA-1 (ANSI/ASME 1986). U.S. Testing is currently developing a QA project plan following EPA guidelines. Its completion is expected before field work begins.

If a laboratory other than U.S. Testing is contracted to provide analytical services, laboratory QA project plans and procedures will be subject to approval by the unit manager and the technical lead prior to initiation of any laboratory testing. These plans and procedures will be required to conform to applicable Westinghouse Hanford policies and procedures.

5.5 CALIBRATION AND PREVENTIVE MAINTENANCE

The term "measurement and test equipment" refers to devices and/or systems used to acquire measurement data or to determine compliance with design specifications or other technical requirements. Measurement and test equipment and reference standards shall be subject to calibration and preventive maintenance in accordance with appropriate Westinghouse Hanford manuals or vendor-supplied procedures. Documented procedures shall be used for calibration and preventive maintenance activities. Where appropriate, these may include published standard practices or written instructions from the vendor that accompany the equipment. For vendor supplied services, the statement of work will require Westinghouse Hanford review and approval of such standard practices and instructions.

5.6 FIELD DEVIATIONS

Field conditions cannot always be sufficiently anticipated during planning efforts. Numerous circumstances encountered in the field can make strict adherence to plans and procedures impossible. These circumstances can include (but are not limited to) equipment limitations, weather conditions, unanticipated soil conditions, previously unidentified barriers, and overly optimistic evaluations of capabilities. Modifications to the planned activity may be necessary when limiting field conditions are encountered. Basically, the following steps will be taken.

- Modifications to the planned activity will be determined that allow completion of the activity objective.
- The conditions of noncompliance, the proposed modifications made to the planned activity, and justification for the modifications will be reported on an instruction change authorization form by the field team leader.
- The field team leader will determine and obtain the required level of management approval based on the impact of the modifications.

Under certain conditions (e.g., a field crew is working in a controlled zone), the field team leader, with concurrence from the site health and

safety officer and the site quality coordinator, may immediately implement an instruction change authorization. The required approvals must subsequently be obtained within two working days of the deviation by the team leader. Rejection of the deviation by the approval authorities will result in repeating the activity at a later date.

5.7 DATA REDUCTION AND REPORTING

This section discusses methods by which the data collected during the RI/FS will be presented. Data management is discussed in Section 8.0. Care will be taken to ensure that traceability is maintained and assumptions are documented so that the more complex presentations do not conceal or distort conditions represented by the raw data. Raw data (the final reported result of a single analysis) will be presented in appendices or in separate data reports to serve as a record of the data collected and to facilitate independent analysis of the results. Raw data will be cited in the report text or reported in figures and tables where appropriate. In addition, data summaries will be prepared to reduce the volume of raw data and to represent basic characteristics with summary statistics. Every attempt will be made to use graphical data presentation where feasible to aid in interpretation by responsible technical staff and other users and reviewers. Where appropriate, statistical hypothesis tests and statements of statistical confidence will also be included.

5.7.1 Raw Data

The most basic form of data presentation is tabulation of raw data. Along with the actual data values themselves, all qualifying information needed to identify the conditions under which the data were collected will be included. Some of these qualifiers are specific to each datum, while others are generic and will be included as headers or footnotes to a data list. They include the following:

- Specific (to be included with each value)
- Location Fully identify location of sample
- Time Fully identify date and time of sampling, and duration of sampling event as appropriate
- Data quality flags Several types of data quality flags will be developed to identify potentially false data and alert data users to conditions that affect the evaluation of the data

- Generic (typically included in headers or footnotes)
- Why sampled Identify the purpose of the data
- How sampled Identify the sampling methods used
- Who sampled Identify who sampled the data (both individual(s) and firms)
- How analyzed Identify analytical methods used
- Who analyzed Identify who analyzed the data (not personnel, but firms)
- Detection limit The detection limit of the analytical procedure should be included with each data point
- Level of concern Where appropriate, levels of concern should be identified, along with identification of the ARAR or other documentation that addresses the level of concern.

In presentation of the data, care will be taken in the number of significant digits reported and data will be reported in comparable units.

5.7.2 Data Summaries

Data summaries will be used to present pertinent characteristics such as counts of samples taken, number of samples above the detection limit (where appropriate), minimum values, maximum values, median and mean values, standard deviations, and coefficients of variation. At this level, potentially complex statistical issues of probability sampling, less-than-detection-limit data, non-normality, variance component analysis, and spatial or temporal correlation will not be addressed. Summaries will be used for different subgroupings of the data as appropriate.

5.7.3 Graphical Presentations

Whenever appropriate, the data will be graphically presented to aid in interpretation. Methods of presentation of spatially variant data will include the two-dimensional graphics with raw data values located on a site map or discrete values indicated by three-dimensional views. Where appropriate, contour plots may be prepared. Generally, contour plots will include locations of raw data values to facilitate evaluation of the gridding and/or interpretation process used in contouring the data.

5.7.4 Statistical Evaluations

Types of statistical analyses that may be appropriate include the following:

- Hypothesis tests between waste site samples and background samples
- Probability statements concerning location(s) and size of "hot spot"
- Statement of statistical confidence level for average contamination levels or total contaminant inventory.

QA data presentations that may be appropriate are the following.

- Field replicate or collocated data and interlaboratory split data will be reported in raw form, as well as relative percent differences, standard deviations, and coefficients of variation. Averages of these three measures will be calculated for similar types of data.
- The total number of field blanks, the number that were above detection limits, and data values above detection limit will be reported.
- Blind standard data will be reported along with the true value, bias, and relative bias for each measurement as well as averages of bias and relative bias for similar types of data.

In addition to sampling and analytical variability, indications of environmental variability and uncertainty are needed to assess the value of the data collected and to evaluate whether or not sufficient data have been collected to characterize the media as required by the DQOs.

For spatial variability, the appropriate measures of variability depend on the amounts and types of data that are collected. For measurements that will typically have relatively few data points, such as air, biota, and groundwater, the data presentation will consist of (as a minimum) the mean, variance, standard deviation, and coefficient of variation for similar types of data. For measurements that have relatively many data points distributed over space, (e.g., soil-gas measurements) geostatistical techniques will be used to provide variance contours.

5.7.5 Identification and Treatment of "Outliers"

As noted in a previous section, data quality flags will be used in reports of the raw data to identify which may be false or inappropriate for evaluation (outliers). Data quality flags will be based on criteria that include the following:

- Values less than detection limits for chemical analyses

- Values less than counting error for radioactive analyses
- Missing values.

Corrective actions may be required when outliers are identified. The procedure for determining corrective actions is described in Section 5.8.4. Corrective actions may include the discarding of the false data and the elimination or correction of the sources.

5.8 AUDITS, SURVEILLANCE, AND DOCUMENTATION

Audits, surveillances, and inspections will be carried out and documented in accordance with applicable sections of appropriate Westinghouse Hanford quality assurance manuals.

5.8.1 Definitions

5.8.1.1 Audit. An audit is a planned and documented activity performed to determine, by investigation, examination, or evaluation of objective evidence, the adequacy of and compliance with established procedures, instructions, drawings, and other applicable documents and the effectiveness of their implementation. Internal audits are audits performed on Westinghouse Hanford activities by Westinghouse Hanford QA auditors or their designees (subcontractors). External audits are audits performed on suppliers and contractors (including analytical laboratories) by Westinghouse Hanford QA auditors or their designees (subcontractors).

5.8.1.2 Surveillance. Surveillance is the act of monitoring or observing to verify whether or not an item or activity conforms to specified requirements.

5.8.1.3 Inspection. Inspection is the act of monitoring or observing to verify whether or not a material, equipment, or hardware conforms to specified requirements.

5.8.2 Frequency and Planning

5.8.2.1 Audits. Internal and external audits of work shall be scheduled at a frequency commensurate with the status and importance of activities. Audit frequency shall include consideration of information from various sources, such as previous audits and program/project schedules.

Audit schedules shall be reviewed and revised as necessary to verify the implementation of the QA program.

Regularly scheduled audits shall be supplemented by additional audits of specific subjects when necessary to enhance the effectiveness of the QA program.

Audits shall be scheduled as early in the life of new activities as practical and shall be continued at intervals consistent with the schedule for accomplishing the activity.

5.8.2.2 Surveillance. Surveillance of activities shall be scheduled at a frequency commensurate with the status and importance of activities. Surveillance frequency shall include consideration of information from various sources, such as previous surveillances and program/project schedules.

A surveillance plan for each activity shall be established at the earliest time consistent with the schedule for accomplishing the activities by the cognizant engineer and the cognizant Quality Engineer and approved by their managers.

5.8.3 Documentation and Reporting

5.8.3.1 Audit. An audit report prepared by auditing personnel shall include the following:

- Description of the audit scope
- Identification of the auditors
- Identification of persons contacted during audit activities
- A summary of audit results, including a statement on the effectiveness of the QA program elements audited
- A description of each audit finding and observation in sufficient detail as to enable corrective action to be taken by the audited organization
- The signature of the audit team leader.

The audit report shall be addressed to the management of the audited organization or to the management having responsibility for response.

5.8.3.2 Surveillance/Inspection. Results of surveillance shall be recorded on an Inspection/Surveillance Report that shall contain the following:

- A discrete tracking number
- The name of the surveillant
- Date of surveillance
- Result of surveillance
- Identification of problem areas

- Identification of any unsatisfactory conditions and the person notified
- Activities surveyed
- Personnel contacted during the survey.

The inspection/surveillance report shall be addressed to management of the activity that has been surveilled or to the management having responsibility for response.

5.8.4 Corrective Action

Corrective actions may be required in response to the findings of surveillance reports, nonconformance reports, or audit activity. Conditions adverse to quality shall be documented and dispositioned in accordance with Westinghouse Hanford policies and procedures. Basically, this procedure entails the identification, investigation, and correction of the conditions adversely affecting quality, and establishes the documentation required to record the process.

Copies of all surveillance, nonconformance, audit, and corrective action documentation shall be routed to the project records upon completion or closure.

6.0 HEALTH AND SAFETY PLAN

6.1 INTRODUCTION

The health and safety plan (HASP) generically addresses potential health and safety issues associated with the RI of several CERCLA sites in the 1100 Area. This chapter will be supplemented by pre-job safety plans (PJSP) that are specific to all health and safety issues for each site investigation activity. Therefore, the information contained herein should be considered as reference material to be used primarily as upper-tier documentation for more job-specific safety plans. The onsite controlling document for risk identification and mitigation will be a Westinghouse Hanford-approved PJSP.

The purpose of the PJSP is to assign responsibilities, specify mandatory operating procedures, establish general personnel protection standards, and provide contingencies for emergency situations that may arise during RI.

This chapter is divided into the following areas for ease of referral. Section 6.2 projects and evaluates the probable hazards associated with the waste sites. Section 6.3 lays out a protection strategy to ameliorate the hazards identified in the previous section. Section 6.4 identifies the recommended and mandatory personnel training requirements necessary to perform remedial investigations. Section 6.5 emphasizes the importance of pre-job safety meetings and monitoring by the site safety officer (SSO). Section 6.6 outlines a preliminary personnel medical surveillance program to track all workers involved in field investigations (the surveillance program will become extremely important if workers are to be used for up to several hundred remedial investigations at the Hanford Site that may eventually be required). Section 6.7 identifies emergency information necessary in case of spills, accidents, environmental releases, and/or injuries. Finally, Section 6.8 identifies the procedures required for individual jobs, the most important of which is the PJSP.

This plan has been prepared in accordance with the requirements established by the EPA (1985c, 1985d) and the National Institute for Occupational Safety and Health (NIOSH) (1985) and meets the requirements outlined by DOE, the Occupational Safety and Health Administration (OSHA), and the State of Washington. However, note that this plan cannot stand by itself unless combined with Section 2.0, "Site Description."

6.1.1 Safety-Related Site Characteristics

From a health and safety perspective, the investigations of the 1100 Area sites will be somewhat unique (from other investigations on the Hanford Site), as depicted in Table 6-1. Therefore, additional precautions may be required as discussed in Sections 6.2 and 6.3.

Table 6-1. Unique Characteristics of 1100 Area Sites.

Waste site	Unique characteristics
1100-1 Battery acid pit	Adjacent to occupied buildings Extensive local traffic (pedestrian, rail, motor vehicle) Relatively close to public drinking water supplies Small dimensions Upwind of commuter traffic Easily visible/not secured
1100-2 Paint and solvent site	Close to rail traffic Relatively close to public drinking water supplies Exact quantities and locations of waste unknown Upwind of commuter traffic Easily visible, not secured
1100-3 Antifreeze and degreaser pit	Close to rail traffic Relatively close to public drinking water supplies Exact quantities and locations of waste unknown Upwind of commuter traffic Easily visible, not secured
1100-4 Antifreeze tank site	Extensive local traffic Relatively close to public drinking water supplies Unknown if tank actually leaked Upwind of commuter traffic Remedial investigation will interrupt maintenance activities Easily visible, not secured
1100-5 Radiation contamination site	Extensive local traffic Exact location unknown Relatively close to public drinking water supplies Upwind of commuter traffic Remedial investigation will interrupt maintenance activities
Horn Rapids landfill	Extensive commuter traffic on two sides Relatively close to public and private drinking water supplies Bottom of cells in or just above groundwater Municipal waste present Extensively large and diverse site Subsidence problems may exist Easily visible, not secured Wide variety of chemicals suspected Could require sampling in vicinity properties Potential pressurized drums, etc. Potential fire or explosion hazards Potential laboratory/hospital waste

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6.1.2 Safety Groupings

Because the majority of these 1100 Area sites are also unique from one another from a health and safety perspective, they are broken down into the following groupings in Section 6.2:

<u>Site groups</u>	<u>Name or number</u>
Horn Rapids	Horn Rapids landfill
Battery acid pit	1100-1
Radiation contamination site	1100-5
All others	1100-2, 1100-3, 1100-4, and "Discolored-soil site".

6.2 HAZARD EVALUATION

Table 6-2 identifies potential safety and health hazards by type of 1100 Area site, as discussed in Section 6.1. In general, the Horn Rapids landfill is believed to present both the largest variety and the most significant of these potential hazards.

Due to the direct disposal or decomposition of solid wastes, methane or hydrogen could be present at some 1100 Area locations. Intermittent combustible gas measurements will be made, with warning levels established at 10% of the lower explosive limit (LEL). All operations will be halted if the LEL exceeds 20%. Precautions will be taken via continuous monitoring if the LEL is between 10% and 20%.

6.2.1 Subsidence

Subsidence is a common problem at the Hanford Site solid waste burial grounds. Precautions shall be taken to prevent injury to personnel or loss of equipment for all 1100 Area sites in which large volumes of solid waste were disposed of (i.e., Horn Rapids landfill). These precautions include bridge-supporting of drill rigs, personnel control, and remote sensing or probing to determine subsidence potential or alternative drilling techniques.

6.2.2 Corrosives

A common hazard to several of the 1100 Area sites, in particular the battery acid pit (1100-1), is the presence of acids. Although soil has some natural buffering capacity, acidified soil is expected to continue to be a hazard to personnel if not handled appropriately and if deep migration has not occurred.

Table 6-2. General Hazards of 1100 Area Sites.

Potential hazard	Waste site			
	Horn Rapids	Battery acid	Radiation contamination site	All others
Methane/flammable gas	X	X	X	
Subsidence	X			X
Corrosives	X	X		X
Heavy metals	X	X	X	X
Organics	X			X
Radiation			X	
Electrical		X	X	X
Heat stress	X	X	X	X
Lighting	X			X
Noise	X	X	X	X
Sanitation	X			X
People proximity	X	X	X	X
Access/egress		X	X	X
Asbestos	X			
Wind-spread contamination	X	X	X	X

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Sulfuric acid can be toxic if inhaled or swallowed; it has a threshold limit value of 1 mg/m³ and can be detected through the use of a colormetric tube. The most likely exposure route is through direct contact with the skin. As a precaution, whole body-level "C" protection, as discussed in Section 6.3, should be considered.

6.2.3 Heavy Metals

Heavy metals, in the form of particulates, are suspected at most sites. Precautions will be taken to prevent the excavation and resuspension of these materials through the use of water mists, excavation permits, and respiratory protection.

6.2.4 Organics

In almost all cases, organics should be assumed to have been disposed of at all of the 1100 Area waste sites, at least in the form of degreasers, antifreeze, and paint solvents. The most significant public health hazard associated with these compounds is inhalation of the vapor. The threshold limit value of common organics are shown in Table 6-3. Most of these compounds are flammable and are toxic if ingested or inhaled.

Direct-reading instruments will be used to detect the possible presence of organics (i.e., photo ionization instruments and organic vapor analyzers). If levels 3 p/m above background in the breathing zone are detected with general survey instruments, personnel will be prepared to cease operations and to fall back to the command post, and monitoring will increase in frequency. If levels 5 p/m over background in the breathing zone are detected, personnel will cease operations and fall back to the command post for further instructions. Levels above background will be investigated to identify the potentially hazardous substance. It is further anticipated that sampling will be conducted for inorganics and organics in addition to monitoring.

More sophisticated trailer-mounted gas chromatograph/mass spectrometer equipment may be used to detect organic vapors in the vadose zone (soil-gas survey) as part of the RI program. Where implemented, the soil-gas survey also shall serve as an early warning system for personnel working on the surface.

When it is anticipated that air-purifying respirators are appropriate (based on the perceived risk at each site), they will be ready and available at the job site for all personnel exposed. The level of initial personnel protection will be dependent on the results of the preliminary assessment (i.e., soil-gas surveys, etc.) and ongoing site monitoring and sampling. The detailed type of respiratory protection will be specified in each PJSP.

6.2.5 Radiation

The radioactive hazards of the RI phase will be controlled by radiation work permits. At this time, the only 1100 Area RI site known to have received radioactive material in any form is the radiation contamination site (1100-5). At present, the 1100-5 site is not considered to be significantly contaminated, pending further review of documentation and other pertinent data. However, precautions should be taken whenever in the general proximity of any radiation contamination site, especially where alpha contamination may be involved.

As a general rule, any site known to have been used for disposal of miscellaneous waste will also be considered a possible radiation contamination site. This includes the disposal pits (1100-2 and 1100-3) and the Horn Rapids landfill. At a minimum, portable detection instrumentation and protective clothing will be required, along with the protective equipment and stationary sampling devices called for in the radiation work permit. Ground surveys conducted of all site surfaces have not revealed any indication of contamination.

Table 6-3. Threshold Limit Values for 1100 Area Site Organics.

Compound	Threshold limit value	
	(mg/m ³) ^a	(p/m) ^b
Methyl ethyl ketone	590	200
Ethylene glycol	125(C) ^c	50(C) ^c (vapor) ^d
Trichloroethylene	270	50
1,1,1 Trichloroethane	1,900	350
Acetone	1,780	750
Toluene	375	100
2-Butanone	590	200
Methylene chloride ^f	350	100
Carbon tetrachloride ^e	30	5 (skin) ^g
Tetrachloroethylene	335	50
1,1,2,2 - Tetrachloroethane	7	1 (skin) ^g

^aThe threshold limit values are time-weighted average concentrations for a normal 8-h workday and a 40-h workweek to which nearly all workers may be repeatedly exposed, day after day without adverse effect.

^bp/m = parts per million.

^cThe (C) indicates ceiling value; concentration should not be exceeded during any part of the working exposure.

^dThe (vapor) notation indicates that substance may act as a simple asphyxiant.

^eSuspected human carcinogen.

^fThese values are anticipated to change to 175 mg/m³ and 50 p/m.

^gThe (skin) notation indicates that cutaneous contamination may be important.

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6.2.6 Electrical Hazards

In some cases, overhead or underground electrical hazards may be encountered. To minimize these hazards, lockout, temporary rerouting, and underground excavation permits will be required for all jobs. When drilling or other large equipment is required, a buffer zone will be established around all overhead hazards, depending on the apparent power rating of the line.

6.2.7 Heat Stress

Heat stress will be a hazard common to all 1100 Area RI, especially when protective clothing must be worn during the summer. The following heat-stress control provisions shall be considered for all 1100 Area RI:

- Solar shielding (tarp/canopy)
- Early day work hours
- Ample cool water and disposable cups
- Routine partial dress-down area within the exclusion zone whenever possible
- Engineered controls (such as refrigerated vests)
- Rest breaks in accordance with the American Conference of Government Industrial Hygienists guidelines (ACGIH 87-88) (1987).

In addition, monitoring of wet bulb globe temperature levels will take place per American Conference of Government Industrial Hygienists guidelines.

6.2.8 Lighting

All field activities are anticipated to be done during daylight hours (with the possible exception of drilling, depending on demand). Adequate portable lighting will be made available for night drilling activities, and light-meter surveys will be provided. Lighting will provide at least 3 fc at the drill hole and 2 fc in the exclusion zone.

6.2.9 Noise

Noise will be a common hazard during RI. A noise survey and routine monitoring will be conducted, and adequate hearing protection will be made available to all employees (generally when noise exceeds 90 dB for extended periods of time). During those times when drill stem casing is being driven, hearing protection will be required in the exclusion zone. Appropriate hearing protection warning signs will be provided outside the exclusion zone.

6.2.10 Sanitation

General sanitation in the RI area will be maintained at all times. Good housekeeping cannot be emphasized enough as continued poor housekeeping invariably leads to accidents.

Remote areas will be provided with portable toilets and solid waste receptacles for team member use. Each command center site will also be provided with fresh potable water (changed out daily), a mechanism for hand washing, and a mobile personnel changing and shower facility wherever possible.

6.2.11 Asbestos

All OSHA, EPA, and Westinghouse Hanford standards and asbestos requirements will be followed for operations in an asbestos environment. All appropriate personnel will be trained either as asbestos workers or as "competent" workers as required by the job.

In general, personnel should be advised that remedial investigation activities are to avoid disturbance of asbestos as much as possible to minimize the airborne hazard.

6.2.12 Wind-Spread Contamination

Because of the arid climate associated with all Hanford Site waste locations, precautions must be taken regarding the potential of spreading contamination by winds. As such, all activities that involve the excavation of potential wastes may be stopped when wind speeds equal or exceed 15 mi/h. Where necessary to control dust and the resultant suspension or natural dusts and contaminants, water mists may be provided.

At each site, containment will be the primary approach to contamination control. This will be supplemented by housekeeping and access control.

6.2.13 Miscellaneous

Because indeterminate amounts of undocumented wastes were disposed of at some of the 1100 Area sites, the potential physical hazards that may be encountered during drilling are numerous. As such, drilling should not be allowed in areas known or highly suspected to contain hazardous waste containers such as drums or potentially pressurized containers.

In the case of the Horn Rapids landfill, there is evidence of some unusual disposal practices that should be discussed during pre-job safety meetings. For example, part of the area was evidently used for sewage/septic disposal, which could contain biological hazards in the form of fungus, heavy metals, and bacteria. In addition, the area was evidently used for either/or both classified-waste and tumbleweed burning. These activities could introduce metallic and radionuclide hazards from newsprint and nuclide uptake, respectively.

Other hazards that must be observed and must have protection provided for are associated with the RI itself. Heavy equipment, utility hoses, pressurized air lines, excavations near buried utilities, and sampling equipment represent tripping, pedestrian, and other hazards for which team members must be alert. Other natural hazards, such as insects and snakes, should also be discussed at safety and planning meetings. Whenever possible, engineered fixes should be provided.

6.3 PROTECTION STRATEGIES

6.3.1 Onsite Control

If radiation is involved or suspected, the SSO and radiation protection technologist are responsible for the coordination and control of access to each 1100 Area RI. A temporary exclusion zone will be established around each drilling and sampling location. A minimum of 25 ft of distance between the perimeter of the zone and the sampling/drilling location will be maintained based on criteria established by the SSO. Each zone will be marked with rope or tape and signs to clearly inform the observer of the potential hazards involved. The ground surface of the area immediately around the drill site and/or sampling location, the corridors to the site command post and the decontamination area, and the escape route will be covered with material to reduce contamination of personnel and equipment if necessary. No unauthorized personnel and only the minimum essential personnel will be allowed inside the exclusion zone.

An onsite command post and staging area, upwind of the exclusion zone, will be established for each 1100 Area RI site unless an adjacent facility or building can be used. Other considerations for the post will include proximity to utilities and access roads and proximity to sampling locations. Consideration will be given to providing a small command trailer for jobs that may last several weeks.

The command post will contain a portable air horn that can be used to alert team members to emergencies. Site-specific procedures will be developed regarding the response to this horn (for example, evacuate the area or return to the command post).

6.3.2 Responsibilities Related to Safety and Health Protection

The field team leader will be named in each PJSP and will control all activities, including the following:

- Allocation of resources necessary for health and safety programs
- Permit verification and supporting documentation
- Technical advice
- Daily communications of daily activities with the SSO
- Conflict resolution
- Emergency response decision making
- Conduct of all pre-job safety meetings.
- Stop work (order).

The SSO will be responsible for implementation of the HASP at the 1100 Area RI sites. These activities include the following:

- Monitoring of all hazards
- Determination of all protection levels and clothing and equipment needs (in conjunction with the radiation protection technologist if radiation is involved)
- Monitoring personnel job performance related to safety procedures
- Stoppage of work for safety violations
- Conduct of safety meetings
- Assistance in the conduct of pre-job safety meetings.

6.3.3 Personnel Protective Equipment

The use of cascade breathing air systems has been standard practice until the unknown organic can be accurately identified and quantified. The levels of protection for nonradioactive hazards will vary between Levels "B," "C," and "D," depending on the detection of contaminants. In general, Level "D," which will be required for all jobs, includes coveralls, substantial footwear (including high-top, leather, steel-toe boots or other material), eye protection, hard hat, gloves, rain suit, booties, hearing protection, and dosimeter (as outlined by the PJSP and checklist).

Where Level "C" is required, the hard hat, safety glasses, and dosimeter will be supplemented by chemical-resistant/surgical gloves, boots, and clothing (e.g., disposable protective coveralls), and a full-face respirator fitted with the appropriate filters (a backup escape mask and/or powered air-purifying respirator may also be required).

It is not expected that Level "A" (i.e., fully encapsulated suit or "moonsuit") with self-contained breathing apparatus will be required for any 1100 Area RI unless unforeseen situations arise. However, the use of cascade breathing air systems, with or without protective clothing (usually considered Level "B"), may be required.

In instances where both radiation and chemical hazards may be present, the radiation work permit will take precedence and will include protective strategies for both radioactive and chemical hazards. For example, organic materials and radioactive material could both occur in the Horn Rapids landfill. Therefore, the appropriate clothing may be a hard hat, chemical-resistant (or disposable) gloves, boots, clothing, and a full-face respirator fitted with both high-efficiency particulate air and organic vapor cartridges. Both types of hazard will be addressed, and a composite protection scheme will be developed.

6.3.4 Communications

A two-way radio will be manned at the command center or will be in the field team leader's possession. Any failure of radio communications will require evaluation of whether or not an evacuation of the exclusion zone will be required (given as a series of three 1-s horn blasts). Usual contact shall be maintained between the team leader and personnel in the exclusion area.

Standard hand signals will be used for all activities:

<u>Signal</u>	<u>Meaning</u>
Hand gripping throat	Out of air, can't breathe
Grip of partner's wrist or both hands around waist	Leave area immediately
Hands on top of head	Need assistance
Thumbs up	Okay, affirmative
Thumbs down	No, negative.

6.4 TRAINING REQUIREMENTS

6.4.1 Remedial Investigation Personnel

Each individual involved in field activities must have 40 h of training in hazardous material handling, encompassing the requirements of 29 CFR 1910.120 and .1200 (OSHA 1985b and 1985a, respectively), to include the following:

- Employee-right-to-know and responsibilities
- Personal protective equipment (use, care, fitting, etc.)
- Hazard identification
- Radiation worker training
- Equipment operation
- Regulatory compliance
- Decontamination procedures
- Emergency response, self-rescue, first aid
- PJSP participation

- Safe sampling techniques
- Communications
- Use of sampling/drilling equipment
- Site control and management
- Hazardous material handling, storage, and transportation
- Use of field test equipment
- Communications with casual observers.

In addition, each new employee will be assigned to a more experienced employee to learn safety practices on the job. All field team participants will participate in at least 8 h of retraining annually.

6.4.2 Field Management Personnel

The SSO and the field team leader are responsible for providing detailed instructions for site-specific procedures, monitoring, equipment operations, and equipment and personnel decontamination procedures. In addition, they must complete the same training as other team members. Note that the decontamination referred to addresses the cleaning, undressing, etc. necessary to minimize health hazards as a partial protection strategy for each RI site.

These field management personnel will receive an additional 8 h of training in handling untrained site visitors, access and egress into control zones, site management, emergency notifications, instrumentation, and other topics related to RI.

All field monitoring equipment will be calibrated in accordance with the manufacturers' specifications. Field management personnel will enter all such data into field log books.

6.5 SAFETY MEETINGS AND INSPECTIONS

Prior to the start of the campaign, a formal pre-job safety meeting will be held by the project/team leader and will be attended by all team members. The HASP will be used as the basis of the PJSP. Both the HASP and the PJSP will be discussed in detail at this meeting. Verification of attendance with signatures will be required. Thereafter, "tailgate" safety meetings will be held at the start of each work day. In addition, on-the-job training will be provided to new employees through a "buddy system."

The SSO and field team leader will make routine inspections of each site and all equipment to ensure that no new safety hazards exist and to monitor activities. The frequency of monitoring/sampling conducted will be dependent

on conditions being experienced and the results of preliminary assessment data analysis. When warranted, a complete dry run of each sampling activity will be provided.

6.6 MEDICAL SURVEILLANCE PROGRAM

6.6.1 Personnel

The names of key personnel who will be at risk during the RI of the 1100 Area sites will be identified in the PJSP. At a minimum, these names will include the field team leader, the SSO, subcontractor employees, the drilling supervisor, and key sampling personnel.

As required by law, personnel who routinely work in or visit an 1100 Area site will be enrolled in a formal medical surveillance program, including those people that do the following:

- Routinely (i.e., >30 d/yr) use respirators
- Are members of the Hanford Hazardous Material Response Team
- Have been or may be exposed to hazardous materials at or above prescribed OSHA or DOE exposure limits or action levels.

6.6.2 Personnel Training

All personnel actively involved in field activities during 1100 Area RI will have successfully completed the initial training required by 29 CFR 1910.120 (24 to 40 h of initial training or equivalent, depending on job hazards) (OSHA 1985b) and will be required to have a minimum of 8 h of retraining as described in Section 6.4. The SSO, field team leader, and members of management and supervision who have direct responsibility for onsite work will receive an additional 8 h/yr in management training. More importantly, each job will be preplanned by a PJSP that will be discussed in detail prior to job startup and again briefly each day that active field investigations take place.

Although the presence of radioactive materials is not anticipated in the 1100 Area, the nature of the work at the Hanford Site is such that the possibility exists. Therefore, Hanford radiation worker training will be required for RI personnel.

All personnel who work in specific areas of the Horn Rapids landfill will be trained as asbestos workers if they must handle or come in contact with the soil samples.

Because some of the 1100 Area sites are within close proximity of the public and other Hanford Site buildings, special training may be provided regarding communications with personnel who may casually observe RI activities. In some cases, a briefing to adjacent building occupants may be appropriate to offset any safety concerns the noninvolved personnel may have.

6.6.3 Medical Examinations

Prior to working at an 1100 Area RI site, key personnel must have received a baseline health assessment under the direction of a licensed physician, nurse, or occupational health professional. This assessment will consist of the following reviews, based on written documentation and discussions of the employee's duties, potential exposure levels, and protective equipment to be used:

- Personal and family medical history
- Existing hazardous material exposure profile
- Standard blood chemistry analysis (including for illicit drug usage)
- Review of any air-sampling data
- Audiometry
- Radiation exposure records
- Physician's assessment to determine fitness for duty.

Whenever questions arise regarding these reviews, additional information may be sought through additional personnel interviews. Supplemental medical examinations shall also be provided to any employees showing signs of sickness, drug abuse, or extended absences for medical reasons.

The examining physician will, in turn, provide respective Hanford contractor management with the results of the examinations and tests, an opinion regarding the employee's readiness for duty, any medical or work restrictions, and a statement that the employee has been informed of the findings of the examination. All Hanford Site contractor personnel will receive occupational health evaluations based on the DOE Site Occupational Health Contractor (Hanford Environmental Health Foundation [HEHF]) procedures and protocol.

6.6.4 Medical Records

The SSO will keep a field notebook with all pertinent information regarding field data related to environmental health information at the site. Information in the field notebook will include the following, at a minimum:

- Dosimetry and time records
- Air and exposure records
- Any observed or known toxicological risks or other hazards
- Personal observations of the job
- Approximate work locations

- Results of examinations, tests, accidents, spills, etc.
- Unusual events
- Other safety-related information.

Until the use of a more sophisticated medical tracking program becomes available, these field notebooks shall be the official medical tracking system for employees in the field. A system similar to the existing Hanford Site radioactive worker dosimetry tracking system is strongly recommended to be established for chemical and physical agents related to RI.

All medical records will be maintained in accordance with 29 CFR 1910.120 (OSHA 1985b) and DOE requirements.

6.7 EMERGENCY INFORMATION

6.7.1 General Information

In case of an emergency, notification will be made through the "811" emergency response number. Because the 1100 Area sites are not in the same emergency response jurisdiction, informing the operator of the location of the problem is important. For example, the Horn Rapids landfill is just north of the Richland city limits; therefore, the Hanford Fire Department/ambulance and Hanford Patrol would respond to any emergency (depending on the severity of the emergency, a cooperative response is also possible). Conversely, the other 1100 Area RI sites are within the city limits; therefore, the Richland Fire and Police Departments would be the first to respond. The dispatcher at the Hanford Fire Department will be notified where work is to be performed at a site before that work begins.

Emergency Telephone Numbers are as follows:

Hanford Site emergency response	811
Richland emergency services	911
PNL emergency response	375-2400
Kadlec Medical Center/Emergency Decontamination Facility	946-4611
Poison Control Center	800-542-5842
National Response Center	800-424-8802
Chemical Transportation Emergency Center	800-424-9300
Chemical Emergency Preparedness Program hotline (SARA Title III information)	800-535-0202
Resource, Conservation, and Recovery Act/ Superfund hotline	800-424-9346
Toxic Substances Control Act hotline	202-554-1404
Safe Drinking Water Act	800-426-4791
Westinghouse Hanford Safety--Gordon Meade	373-3948
Westinghouse Hanford Site Safety Officer --Jim Mohatt	373-5566
PNL Safety--Tom McLaughlin	376-0499

6.7.2 Emergency Procedures

Communications will be maintained during all onsite field activities by two-way radio contact. If an emergency occurs, such as fire or explosion, all onsite personnel should exit the site in an upwind direction and assemble in a predesignated area. All emergency response actions for each job will be covered in the tailgate meeting with the PJSP. If an onsite emergency occurs, the procedures that follow should take place.

- Upon notification of an injury in the exclusion zone, the emergency signal of three 1-s horn blasts will be sounded. All site personnel will assemble at the decontamination line. If the injured persons cannot walk to the decontamination line, they will be removed to the decontamination line only if moving them is required to prevent greater risk from the contaminants than would occur from moving the individual prior to arrival of emergency personnel. The decision to move an injured individual will be based on an evaluation of the injury and the contamination hazard. The SSO and the field team leader should evaluate the nature of the injury and the extent of decontamination possible prior to movement of the injured person to the support area. Appropriate first aid should be initiated, and an ambulance summoned, if required. No person should reenter the exclusion zone until the cause of the injury is determined and measures are taken to prevent recurrence.
- Upon notification of an injury in any support area, the SSO and the field team leader will assess the nature of the injury. If the cause of the injury or loss of the injured person does not affect the performance or safety of site personnel, operations may continue, with initiation of first aid and summoning of ambulance, if required. If the injury increases the risk to others, the emergency signal of three 1-s horn blasts will be sounded and all site personnel shall move to the decontamination area for further instructions. Activities onsite will stop until the added risk (if any) is evaluated and reduced to an acceptable level.
- Upon notification of a fire or explosion onsite, the emergency signal of three 1-s horn blasts will be sounded and all site personnel will assemble at the decontamination line. The fire department will be notified by the SSO and all personnel will move to a safe distance from the involved area. Again, based on the individual tailgate meetings, a decision to send all personnel immediately out of the exclusion area may be an option.
- If any worker experiences a failure of protective equipment that affects the protection factor, that person and his or her buddy shall immediately leave the exclusion zone. Reentry shall not be permitted until the equipment has been repaired or replaced or the conditions leading to the problem are adequately evaluated and corrected.
- If onsite equipment fails to operate properly, the SSO and the field team leader shall be notified and then determine the effect of the failure on continuing operations. If the failure affects

the safety of personnel or prevents completion of the work plan tasks, all personnel shall leave the exclusion zone until the necessary repairs are made.

- In the event that an emergency situation prevents exiting the exclusion zone by way of the decontamination area, exit the exclusion zone in any direction, preferably upwind.
- If an injury to a worker involves chemical exposure, the following first aid procedures are to be instituted as soon as possible:
 - Eye Exposure. If contaminated solid or liquid gets into the eyes, wash eyes immediately with an emergency eye wash using large amounts of water and lifting the lower and upper lids occasionally (an emergency eye wash station will be provided in the field). Obtain medical attention immediately.
 - Inhalation Exposure. If a person inhales large amounts of organic vapor, that person should be moved to fresh air at once. If breathing has stopped, perform artificial respiration. If breathing and heart have both stopped, perform cardiopulmonary resuscitation (CPR). Obtain medical attention immediately. Keep the person warm and at rest until medical help arrives.
 - Skin Exposure. If contaminated solids or liquids get on the skin, promptly use the deluge water unit, then wash contaminated skin using soap or mild detergent and water. If solids or liquids penetrate through the protective clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Obtain medical attention immediately if symptoms warrant.
 - Ingestion. If contaminated solid or liquid has been swallowed, immediately obtain medical attention and call the Poison Control Center. In these situations, if 811 is not notified, the person should be taken to the nearest first aid station.
- Although radiological exposures are not anticipated in the 1100-EM-1 operable limit, the nature of work at the Hanford Site is such that the possibility exists. If any form of radioactive contamination of either personnel or equipment is detected or suspected by the radiation protection technologist, SSO, field team leader, or the affected individual, then appropriate decontamination procedures and immediate first aid, if necessary, will be administered by a trained radiation protection technologist. As a precautionary measure, the radiological action and warning levels will be detailed in each separate PJSP issued for each individual site.

6.8 NEEDED DOCUMENTS

The PJSP provides specific safety procedures and requirements for each activity at each RI site. These are developed on an individual basis and will be available at the work site. These documents will address, at a minimum, the following:

- Site- and activity-specific health and safety issues
- Standard operating procedures
- Personnel requirements
- Standards on protective equipment and risk mitigation
- Site-specific limits, warning levels, instrument requirements, and measurement frequency for air and exposure monitoring
- Routine and emergency decontamination procedures
- Site-specific emergency procedures.

Safe work practices that can be generally applied to all RIs are the following.

- Hard hats, safety glasses, and steel-toe boots will be worn when inside the exclusion zone.
- Eating, drinking, chewing gum or tobacco, or smoking will be prohibited in the exclusion zone.
- No facial hair that interferes with face-to-mask seal of respirators or self-contained breathing apparatus will be allowed.
- No contact lenses will be worn.
- Personnel shall avoid direct contact with contaminated materials unless necessary for sample collection or required observation. Remote handling of casing, auger flights, etc., will be practiced whenever practical.
- Personnel not involved in operation of the cable-tool drill rig or monitoring activities shall remain a safe distance from the rig as indicated by the field team leader.
- Following decontamination or whenever leaving the exclusion zone, personnel should wash face and hands thoroughly.
- At the end of each work day or each job, disposable clothing shall be removed and placed in drums or plastic-lined "rad" boxes. Clothing that can be cleaned shall be sent to the Hanford Laundry.

- Individuals are expected to thoroughly shower as soon as possible after leaving the job site if directed to do so by the radiation protection technologist, site safety officer, or field team leader.
- Personnel shall use the "buddy system" at all times while operating in the exclusion zone.
- Personnel shall maintain a high level of awareness of the limitations in mobility and dexterity, and of the visual impairment inherent in the use of Level "B" and Level "C" personal protection equipment.
- All drilling operations personnel will be aware of the position of every person in regard to rotating equipment, cat heads, U-joints, etc., and will be extremely careful when assembling, lifting, and carrying auger flights or drill pipe to avoid pinch point injuries and collisions.
- Tools and equipment will be kept off the ground whenever possible to avoid tripping hazards and the spread of contamination.
- The "buddy system" will be used for all manual lifting.
- All team personnel are required to attend a pre-job safety meeting prior to the start of the campaign.
- A mandatory "tailgate" meeting will be conducted prior to each hole-drilling operation.
- All work operations onsite shall cease at sunset, unless the entire control zone is adequately illuminated with artificial lighting. A new tour (shift) will man the rig after completion of each shift.
- Requirements of general regulations and practices for radiation work shall be followed for all work involving radioactive materials or radioactive contamination.
- Team members will attempt to minimize truck tire disturbance of all stabilized sites.
- If safety concerns arise during the course of the field study that are not satisfactorily addressed by this safety plan or the subsequent pre-job safety plan, work will be stopped until the site safety officer and the field team leader evaluate and resolve the concerns. Employees are encouraged to bring up any safety concerns to the site safety officer or field team leader.
- Under most circumstances, crews working on a hazardous waste site will work no longer than an 8-h shift.

7.0 TECHNOLOGY PLAN

The technology plan describes the process by which the FS is conducted and identifies and evaluates remedial alternatives. The approach for determining the appropriate remedial response is divided into three phases. In Phase I, the analysis of the impacts resulting from no RA is performed, and possible treatment technologies are identified. The ARARs, their justification, and their points of application are also addressed in Phase I. The ARARs include the definition of contaminant concentrations that are protective of the environment and human health. Methods to combine treatment technologies into specific remedial alternatives are provided in the SARA guidance for conducting Phase I of the FS. The screening methodology for the elimination of inappropriate or least attractive remedial alternatives is provided in Phase II guidance. A detailed evaluation and comparative analysis of the alternatives is conducted in Phase III. These analyses provide the basis for selection of the remedial alternatives by the decision makers during the ROD process.

A transport-pathways analysis, performed for the no-action alternative in Phase I of the FS, determines the populations at risk and the mode of exposure creating the risk. The difference between ARARs (including accepted health-based risk levels) and the level of risk for the no-action alternative determines the degree of remediation needed. This analysis forms the basis for establishing remedial response objectives and criteria for developing appropriate remedial alternatives. The pathways of concern (e.g., air, surface water, etc.) are other important factors.

Screening of the remedial alternatives occurs in Phase II of the FS. The work tasks necessary to meet this objective include preliminary evaluation of the ability of remedial alternatives to meet performance requirements, development of criteria for screening remedial alternatives, and screening and elimination of the lower-ranked remedial alternatives.

The final phase (Phase III) is an evaluation of a detailed analysis of the alternatives to provide the basis for selecting an alternative during the ROD process.

7.1 CLEANUP OBJECTIVES AND REQUIREMENTS

In developing a methodology for evaluating potential remediation technologies, the ability to determine the desired end goals of the remedial action is important. Federal, State, and local regulations and guidelines are important factors in the determination of remediation goals. According to the CERCLA as amended by the SARA, ARARs must be considered in selecting waste cleanup remedies. This section of the technology plan provides a brief overview of the regulatory environment and requirements that will serve as the basis for screening and selecting remedial measures for the 1100-EM-1 operable unit.

Regulatory requirements, standards, and other guidance are important to consider in assessing the acceptability of technology options for remediation of a particular site. These standards serve as guidance to the engineers in

terms of the level of cleanup required and may make obvious the advantage of one technology over another. An understanding of potential ARARs can also help determine data-collection and site-characterization needs and direct the sampling and evaluation programs for a site. Identifying data collection needs and restrictions on technology options streamlines the processes for site characterization and technology screening/selection.

Regulation-driven requirements are only one of a variety of important factors that need to be considered in the full cleanup process. Some of the regulation-driven requirements that need to be considered in the technical evaluation include the following:

- Identification of potential ARARs
- Development of standards or equivalent guidance where ARARs do not exist
- Definition and development of RA objectives
- Clarification of the locations within the site at which compliance with the regulations or RA objectives must be met.

The following sections of the technology plan present a brief discussion of these four requirements. The identification of ARARs and the development of regulatory guidance for technology screening and remediation is an interactive and iterative process. The following material is intended to describe the concepts and provide a starting point for that process for the 1100-EM-1 operable unit.

7.1.1 Identification of Applicable or Relevant and Appropriate Requirements

Remedial actions at a "Superfund" site must be in compliance with a number of requirements under Federal and State environmental laws, generally termed ARARs. This section of the work plan identifies the potential ARARs for the 1100-EM-1 operable unit.

The EPA's Interim Guidance on Compliance with Applicable or Relevant and Appropriate Requirements (EPA 1987c) describes the following three types or classifications of ARARs.

- Ambient or chemical-specific requirements that set health or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. Examples include maximum contaminant levels (MCL) under the Safe Drinking Water Act of 1974 and national ambient air quality standards under the Clean Air Act of 1977.

- Performance, design, or other action-specific requirements that set controls or restrictions on particular kinds of activities related to management of hazardous substances, pollutants, or contaminants. Examples include RCRA regulations for closure of hazardous waste storage or disposal facilities, and Clean Water Act of 1977 pre-treatment standards for discharge to publicly owned treatment works.
- Locational requirements that set restrictions on activities with regard to the characteristics of a site or its surrounding environment. Examples include Federal and State siting laws for hazardous waste facilities.

The EPA interim guidance also states that standards or requirements contained in nonpromulgated advisories or guidance documents issued by Federal or State governments or agencies do not have the status of ARARs. However, they may be considered or used as reference criteria in determining the necessary level of cleanup for protection of public health or the environment. When no ARARs exist or existing ARARs are not sufficient to be protective, health advisory levels such as reference doses or carcinogenic potency factors should be identified to ensure protectiveness of a remedy, or alternative criteria for cleanup may be developed as described in Section 7.1.2 of this work plan.

The broad array of potential chemical-specific ARARs for the 1100-EM-1 operable unit are identified in Tables 7-1 and 7-2. Explanatory notes for the material presented in these tables are contained in footnotes to the tables. Additional guidance that may be relevant to identifying remediation alternatives is also included in the tables. The guidance values have been included to provide information for developing RA objectives that will ensure public and environmental protection and may be appropriate for use when no actual ARARs exist for a particular contaminant. The columns for EPA drinking water health advisories and toxicity data on Table 7-1, for example, fall under this description. Action- and location-specific potential ARARs have not been developed as part of this work plan. Action-specific ARARs are generally specific to technologies or technology types; thus, they should be developed after technology screening. Location-specific ARARs, such as those under cultural resource and wildlife protection statutes, must also be developed.

The lists provided in Tables 7-1 and 7-2 are an initial identification of the potential ARARs that may apply to the contaminants potentially present within the 1100-EM-1 operable unit. The specific applicability of these ARARs to the 1100-EM-1 operable unit must still be investigated. However, this list of potential ARARs can be used for screening of remedial alternatives and associated technologies and will provide a broad basis on which to determine actual ARARs.

Table 7-1. Potential Applicable or Relevant and Appropriate Requirements and Other Guidance.
(sheet 4 of 5)

	Federal air quality standards	Federal and State drinking water standards			CERCLA reportable quantities (lb)	Toxicity data ^{a,e}				TSCA ^f	EPA drinking water health advisories ^{a,h}					RCRA and WAC waste designation and concentration limits			
		MCL (mg/L)	MCLG (mg/L)	SMCL (mg/L)		ADI (mg/kg-d)		CoF (mg/kg-d) ^{a,g}			1 d 10-kg infant (µg/L)	10 d 10-kg infant (µg/L)	Longer term 10-kg infant (µg/L)	Lifetime 70-kg adult (µg/L)	Reference concentration for potent air carcinogen (ng/L)	Toxicity	EP toxicity (mg/L)	Contaminant levels in groundwater (mg/L)	
						AIS	AIC	Oral	Inhal.										
Halogenated and nonhalogenated hydrocarbons																			
Benzene	(b)	0.005	0	--	1,000	--	--	5.20 x 10 ⁻²	2.60 x 10 ⁻²	--	233	233	NA	NA	NA	0.35	C	--	--
Xylene	--	--	0.449	--	1,000	0.1	0.01	--	--	--	12,000	7,800	7,800	27,300	2,200	NA	C	--	--
Toluene	--	--	2.09	--	1,000	0.43	0.3	--	--	--	18,000	6,000	--	--	10,800	NA	C	--	--
Methylene chloride	--	--	--	--	1,000	--	--	--	--	--	--	--	--	--	--	--	C	--	--
TCE, trichloroethylene	--	0.005	0	--	1,000	--	--	0.011	4.6 x 10 ⁻³	--	--	--	--	--	--	2.8	C	--	--
Carbon tetrachloride	--	0.005	0	--	5,000	--	--	0.13	--	--	4,000	160	71	250	--	0.3	D	--	--
Tetrachloroethylene	--	--	09	--	1.0	--	0.02	0.051	0.0017	--	--	34,000	1,940	6,800	--	0.7	X	--	--
1,1,1 trichloroethane	--	0.20	0.20	--	1,000	--	0.54	--	--	--	140,000	35,000	35,000	125,000	1,000	22,000	C	--	--
TCA, trichloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--
Selected chemical constituents in the 1100 Area operable unit																			
Mercury	≤ 2,300 g/24h ≤ 3,200 g/24h	0.002	0.003	--	1.0	0.002	0.002	--	--	--	--	--	--	--	5.5	NA	X	0.2	0.002
Chromium	--	0.05	0.12	--	1.0	0.025 (hexavalent)	0.005 (hexavalent)	--	--	--	1,400	1,400	240	840	170	NA	X	5.0	0.05
Arsenic	< 2.3 Mg/yr ^a < 0.4 Mg/yr	0.05	0.05	--	--	--	--	1.5 x 10 ⁵	50.0	--	50	50	50	50	50	0.0022	X	5.0	0.05
Lead	1.5 µg/m ³	0.05	0.02	--	--	--	0.0014	--	--	--	--	--	20 µg/d	20 µg/d	20 µg/d	0.031	X	5.0	0.05
Nitrate ^a	--	10	10	--	--	--	0.01 ⁱ	--	--	--	10,000 (4 kg) 1.1 x 10 ⁵ (10 kg)	10,000 (4 kg) 1.1 x 10 ⁵ (10 kg)	--	--	10,000	NA	--	--	10.0
Sulfate	--	--	--	250	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ethylene glycol	--	--	--	--	--	--	--	--	--	--	19,000	5,500	5,500	19,250	--	NA	D	--	--
PCBs	--	--	0.0	--	10.0	--	7.7 ⁱ	4.34	--	Restricted access ^f area: 25 p/m Nonrestricted access area: 10 p/m	--	--	--	--	--	--	A	--	--
Di-N-Octyl phthalate	--	--	--	--	5,000	--	--	--	--	--	--	--	--	--	--	--	D	--	--
Bis-(2-Ethylhexyl) phthalate	--	--	--	--	1.0	--	0.02	6.84 x 10 ⁻⁴	--	--	--	--	--	--	--	--	X	--	--

Table 7-1. Potential Applicable or Relevant and Appropriate Requirements and Other Guidance. (Sheet 2 of 5)

ADI = Acceptable daily intakes.
 AIC = Acceptable intake for chronic exposure.
 AIS = Acceptable intake for subchronic exposure.
 CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
 CpF = Carcinogenic potency factor.
 EP = Extraction procedure.
 EPA = U.S. Environmental Protection Agency.
 MCL = Maximum contaminant level.
 MCLG = Maximum contaminant level goal.
 RCRA = Resource Conservation and Recovery Act.
 SMCL = Secondary maximum contaminant level.
 TSCA = Toxic Substances Control Act.
 WAC = Washington Administrative Code.

^aThese data are guidance material found in the EPA guidance document (EPA 1986b). As such, they cannot be ARARs, but may be relevant.

^bThis column outlines the standards identified under the Clean Air Act of 1977 and implementing regulations (EPA 1981, 1982). The basic purpose of the Clean Air Act is to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Its implementing regulations are found in EPA regulations (1981, 1982). The State standards are available in the Washington Administrative Code (Ecology 1972) and General Regulation 80-7 of the Benton-Franklin-Walla Walla Counties Air Pollution Control Authority (1980). These regulations contain no numerical standards for and of the listed constituents in the 1100-EM-1 operable unit.

Mercury -- The mercury standards from 40 CFR 61.52(a) and (b) (EPA 1982) present standards for emissions to the atmosphere from (1) mercury ore processing facilities and mercury cell chlor-alkali plants and (2) sludge incineration or sludge drying plants, respectively. For either of these type of plants, mercury emissions shall not exceed the given numerical standard in any 24-h period.

Arsenic -- The arsenic standards given in 40 CFR 61.162(a) and (b) (EPA 1982) are specific to uncontrolled emissions from glass-melting furnaces. These uncontrolled arsenic emissions must be less than the given numerical standard during any 1 yr.

Lead -- The lead standard is from 40 CFR 50.12 (EPA 1981). The pollutant is measured by a maximum arithmetic mean averaged over a calendar quarter.

Benzene -- The benzene standard given in 40 CFR 61.110 (EPA 1982) is specific to benzene leaks from pumps, compressors, pressure-relief devices, sampling connections, systems, open-ended valves or lines, valves, flanges and other connectors, product accumulator vessels, and control devices or systems. Standards and repair time frames relating to failure of seals, valves, and other leak control systems are available in the regulations for each piece of equipment listed above. As such, these standards and requirements have no ready applicability to the source of benzene in the 1100 Area operable unit.

^cFederal and State drinking water standards: MCLs, MCLGs, and SMCLs. The purpose of the Safe Drinking Water Act of 1974 (EPA 1986a and 1987e, respectively) and its 1986 amendments is to protect public health by protecting drinking water sources. The Federal implementing regulations for the Act include the National Primary and Secondary Drinking Water Regulations in 40 CFR 141 and 143 (EPA 1986a and 1987e), respectively. The State of Washington is authorized to administer the public water supply regulations set forth under the Act. These State implementing regulations are found in WAC 248-54, (Ecology 1983).

The primary drinking water standards are set in two stages for each contaminant: a maximum contaminant level goal (MCLG), which is the level at which no adverse health-based effects would arise with a margin of safety, and a maximum contaminant level (MCL), which sets enforceable levels as close to the MCLG as is feasible, taking cost, lab capability, and other factors into account. These standards are set nationally and are enforced principally by the states. The secondary maximum contaminant levels (SMCL) are given for contaminants that may adversely affect the odor or appearance of water and serve as guidelines to the states (as such, they are not enforceable).

The MCL and SMCL values for the selected constituents in the table are the same in both the Federal and State regulations, while the MCLGs are strictly Federal guides. The MCL for nitrate is for measuring nitrate as nitrogen.

^dThe basic purpose of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) is to provide funding and enforcement authority both for responding to releases of hazardous substances to the environment and for cleaning up abandoned or inactive waste sites (i.e., spills, discharges, etc.). The implementing regulations for this Act are found in 40 CFR 300 and 302 (EPA 1985f and 1985a, respectively). In EPA (1985a) Table 302.4, there is a list of CERCLA-defined hazardous substances and their reportable quantities. The presence of these substances in quantities equal to or greater than their reportable quantities require notification to the National Response Center and subsequent removal, remediation, or both.

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Table 7-1. Potential Applicable or Relevant and Appropriate Requirements and Other Guidance. (Sheet 3 of 5)

^eToxicity Data. The data in this column came from two sources: the EPA's Integrated Risk Information System--IRIS (via phone conversation with Dana Davoli - EPA Region 10), and the EPA (1986) (hereafter referred to as "Superfund Manual"). Since these data are from guidance material, they cannot produce potential ARARs because of the definition of ARAR in Interim Guidance on Compliance with Applicable or Relevant and Appropriate Requirements, (EPA 1987c). However, the data may be considered to be necessary in ensuring protectiveness and may be appropriate for use in specific alternatives.

As discussed in the Superfund Manual, three values describe the degree of toxicity posed by a chemical:

- The acceptable intake for subchronic exposure (AIS)
- The acceptable intake for chronic exposure (AIC)
- The carcinogenic potency factor (CpF).

The AIS and AIC values fall under the category of acceptable daily intakes (ADIs), which are similar in concept to EPA-verified reference dose values. The AIS and AIC values are derived from information, obtained through animal studies (or human epidemiologic studies if available) on the relationship between intake and noncarcinogenic toxic effects.

Acceptable Intake for Subchronic Exposure Values -- Most AIS values are based on subchronic (10 to 90 d) animal studies with some values derived from human exposure data. In most instances, an uncertainty factor of 10 is used to account for intraspecies variability (the fact that two individuals of the same species may not react to the same quantity of a chemical with the same level of response).

Acceptable Intake for Chronic Exposure Values -- The AIC values are generally based on long-term animal studies except where adequate human data are available. The same uncertainty factors found in AIS values are used when accounting for animal-human extrapolation and intraspecies variability. When chronic studies are not available for a particular chemical, values from subchronic studies are used and divided by an additional factor of 10 to account for extrapolating from subchronic to chronic.

Carcinogenic Potency Factors -- The CpF are upper 95% confidence limits on the slope of the dose-response curve for chemical carcinogens. These factors are used as an upperbound estimate of potential carcinogenic risk and are expressed as the lifetime cancer risk per milligram per kilogram of body weight per day. The CpFs are established for both an oral route and an inhalation route.

^fToxic Substances Control Act of 1976 (TSCA) - PCB Cleanup Policy. The purpose of the Act is to identify and evaluate potential hazards from chemical substances and to regulate the production, use, distribution, and disposal of these substances. Implementing regulations for this Act include Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (EPA 1984). Subpart G is entitled "PCB Spill Cleanup Policy" (hereafter referred to as "Policy") and was originally published as a policy rule. The Policy establishes measures that EPA considers to be adequate for the cleanup of PCB contamination from activities regulated under the TSCA.

The scope of this Policy states that "...spills which occurred before the effective date of this policy [July 1, 1987] are to be decontaminated to requirements established at the discretion of EPA, usually through its regional offices" (EPA 1984). This section excludes spills directly into surface waters, drinking waters, sewers, grazing lands, and vegetable gardens from application of final numerical cleanup standards. For all other spills, EPA generally expects the final cleanup standards contained in the Policy to apply. Depending on the circumstances of a spill, EPA retains the flexibility to require or allow different or more stringent cleanup requirements due to site-specific considerations such as the following:

- Additional routes of exposure
- Factors that may mitigate exposures and risk or make cleanup to the standards impracticable (EPA 1984).

The EPA will apply this flexibility if the responsible party demonstrates that compliance to the cleanup level is clearly unwarranted because of the following:

- Risk-mitigating factors
- Impracticability at a particular site
- Site-specific characteristics that make the costs of cleanup prohibitive (EPA 1984).

Section 761.125, (EPA 1984), which contains the requirements for PCB spill cleanup, is divided into two parts: requirements for cleanup of spills involving < 1 lb PCBs by weight requirements for cleanup of spills involving 1 lb or more PCBs by weight. Discussions of both are presented below.

Spills Involving Less Than One Pound PCBs by Weight -- For spills involving < 1 lb PCBs, all solid surfaces (metals, glass, wood, asphalt, etc.) must be double washed/rinsed and all soil must be excavated within the spill area (i.e., visible traces of soil and a buffer of one lateral foot around the visible traces). The ground must be restored to its original configuration by back-filling with clean soil (i.e., containing less than 1 p/m PCBs). A double wash/rinse involves cleansing solid surfaces two times with an appropriate solvent or other material in which the PCBs are at least 5% soluble (by weight).

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Table 7-1. Potential Applicable or Relevant and Appropriate Requirements and Other Guidance. (Sheet 4 of 5)

Spills Involving One Pound or More PCBs by Weight -- Decontamination requirements for these spills are dependent upon the following two types of areas:

- **Restricted Access Areas.** Areas other than electrical substations that are at least 0.1 km from a residential/commercial area and limited by man-made barriers (e.g., fences and walls) or substantially limited by naturally occurring barriers such as mountains, cliffs, or rough terrain (40 CFR 761.123) (EPA 1984).
- **Nonrestricted Access Areas.** Areas other than restricted access, outdoor electrical substations, and other restricted access areas. These areas include residential/commercial areas as well as unrestricted access rural areas (areas of low-density development and population where access is uncontrolled by either man-made barriers or naturally occurring barriers) (40 CFR 761.123) (EPA 1984).

Cleanup requirements for these two types of areas are available for various surfaces and soil with only those standards for soil being given here.

For restricted access areas, soil that is contaminated by a spill involving 1 lb or more of PCBs must be cleaned to 25 p/m PCBs by weight [40 CFR 761.125(c)(3)(v)] (EPA 1984).

For nonrestricted access areas, soil that is contaminated by a spill involving 1 lb or more of PCBs must be cleaned to 10 p/m PCBs by weight provided that the soil is excavated to a minimum depth of 10 in. The excavated soil must be replaced with clean soil (i.e., containing less than 1 p/m PCBs), and the spill site will be restored (e.g., replacement of turf) [40 CFR 761.125(c)(4)(v)] (EPA 1984).

^gThese are proposed MCLGs that have not yet been finalized (EPA 1985e).

^hEPA Drinking Water Health Advisories. In the Superfund Manual, EPA provides guidance, in the form of nonregulatory health advisories, for various chemicals found in drinking water. This guidance presents health advisories that are based on the concentrations of contaminants in drinking water at which no adverse effects to human health would be expected to occur. A margin of safety is factored in to protect sensitive members of the population such as infants. Because the data are from guidance material, they cannot produce potential ARARs due to the definition of ARAR in Interim Guidance on Compliance with Applicable or Relevant and Appropriate Requirements, (EPA 1987c). However, the data may be considered to be necessary in ensuring protectiveness and may be appropriate for use in specific alternatives.

One-Day and Ten-Day Health Advisories -- The quantities in both of these categories are calculated for a 10-kg child (a one-year old infant) assumed to drink 1 L of water per day.

Longer-Term Health Advisories (Several Months to Several Years of Exposure) -- The quantities in this category are calculated for both a 10-kg child and a 70-kg adult assumed to drink 1 L and 2 L of water per day, respectively.

Lifetime Health Advisories -- The quantities in this category are calculated for a 70-kg adult assumed to drink 2 L of water per day.

Reference Concentration for Potential Carcinogen -- The quantities in this category, if found in drinking water, are to be associated with a projected upper 95% confidence limit excess lifetime cancer risk of 10^{-6} . Comparing these values to actual concentrations in drinking water can provide an indication of the magnitude of potential carcinogenic risk.

ⁱToxicity, EP Toxicity, and Concentration Limits in Groundwater (RCRA and WAC). The Resource Conservation and Recovery Act of 1976 (RCRA) regulates the management of hazardous waste from generation to disposal. With the exception of the 1984 amendments to RCRA (Hazardous and Solid Waste Amendments of 1984), authority to implement RCRA has been delegated to the State of Washington. The State of Washington Hazardous Waste Management Act (1976) and its implementing regulations (Ecology 1987a) set forth the State requirements for regulating hazardous waste.

Toxicity Column. This column presents lists categories representing the toxicity of each identified chemical constituent. The categories, in descending order of toxicity, are X, A, B, C, and D. The quantitative difference between each category is a factor of 10 (e.g., X is 10 times more toxic than A, and 100 more than B. A is 10 times more toxic than B, etc.). The toxicities, when used in conjunction with the weight percent of each toxic constituent present in a waste mixture, can be used to calculate the equivalent concentration and determine if the waste mixture will be designated as a dangerous or extremely hazardous waste (WAC 173-303-084) Ecology 1987a. The procedures used to calculate equivalent concentrations and to designate a waste are available in WAC 173-303-9903 (Ecology 1987a). Toxicity classifications for some constituents are found in the fourth column of the discarded chemical products list in Ecology (1987a). In addition, the requirements of RCRA (1976) specify that the constituents in mixtures must also be checked against the toxicities given in column 7 of Table 302.4 of EPA (1985a) and those given in the National Institute for Occupational Safety and Health's (NIOSH) Registry of Toxic Effects of Chemical Substances [WAC 173-303-084 (2)] (Ecology 1987a). The toxicity of ethylene glycol was obtained from data in the NIOSH Registry. The toxicities of the other constituents in the column were taken from Table 302.4 of EPA (1985a). Trichloroethane was assigned to toxicity category "X" because trichloroethane is assumed to be a mixture of 1,1,1 trichloroethane (toxicity C) and 1,1,2 trichloroethane (toxicity X). For situations in which insufficient information on constituents has been provided, the more stringent toxicity assignment is used.

After a waste has been designated as nonhazardous, dangerous, or extremely hazardous, disposal options can be evaluated. For example, some disposal methods will not be allowed for extremely hazardous waste. As of February 5, 1988, new land disposal restrictions (Ecology 1987a) became effective that prohibit land disposal of various classes of waste.

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Table 7-1. Potential Applicable or Relevant and Appropriate Requirements and Other Guidance. (Sheet 5 of 5)

In addition to toxicity, wastes and waste mixtures can be designated as dangerous or extremely hazardous based on: how the waste was discarded (WAC 173-303-081), the sources of the waste (WAC 173-303-082), persistence and carcinogenic properties (WAC 173-303-084), characteristics of the waste (WAC 171-303-090), and dangerous waste criteria (WAC 173-303-101, 102, 103) (Ecology 1987a). For example, a waste is considered persistent and dangerous if more than 100 kg are present, and the total organic halogen concentration exceeds 0.01% by weight.

EP Toxicity Column—The values presented in this column are available in the EP Toxicity List in WAC 173-303-090 (Ecology 1987a). The values apply to the liquid extract of a waste and not to the actual waste and result in the designation of a waste as dangerous or extremely hazardous.

Concentration in Groundwater Column—This column presents concentration limits for constituents that must not be exceeded in the groundwater underlying a hazardous waste management area.

^jThese standards are for mercury ore processing facilities and mercury cell chlor-alkali plants; and sludge incineration or sludge drying plants, respectively.

^kThese standards are for uncontrolled emissions from existing and new glass melting furnaces, respectively, and are in units of megagrams per year.

^lFrom telephone conversation with Dana Davoli - EPA Region 10.

^mThe 1- and 10-d health advisories for nitrate are given for both a 4-kg newborn and a 10-kg infant.

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Table 7-2. Potential Applicable or Relevant and Appropriate Requirements for Selected Radionuclides in the 1100 Area Operable Unit. (sheet 1 of 2)

Reportable quantities	CERCLA ^a reportable quantities (Ci)	Federal and State ^b drinking water standards (pCi/L)	Federal air quality standards ^c	10 CFR 20 (NRC 1979) emission limit concentrations in air and water above natural background ^d				Environmental radiation protection standards for radioactive waste disposal ^e	
				Air (μCi/m ³)		Water (pCi/mL)		40 CFR 191	40 CFR 193
				Soluble	Insoluble	Soluble	Insoluble		
Gross alpha	—	15	(f)	—	—	—	—	—	—
Gross beta	—	<50 ^g	(g)	—	—	—	—	—	—
Gross gamma	—	—	(h)	—	—	—	—	—	—
Plutonium oxide ^h	—	—	(i)	(h)	(h)	(h)	(h)	(h)	—
Americium-241	10.0	—	(j)	2 x 10 ⁻¹³ (d)	4 x 10 ⁻¹² (d)	4 x 10 ⁻⁹ (d)	3 x 10 ⁻⁹ (d)	100 Ci/unit of waste ^e	—
Cesium-137	0.01	—	(k)	2 x 10 ⁻⁹ (d)	5 x 10 ⁻¹⁰ (d)	2 x 10 ⁻⁹ (d)	4 x 10 ⁻⁹ (d)	1,000 Ci/unit of waste ^e	—
Dose equivalents	—	4 mrem/yr ^g	Whole body: 25 mrem/yr Critical organ: 75 mrem/yr Alternate Standards Continuous exposure: 100 mrem/yr Noncontinuous exposure: 500 mrem/yr (l)	—	—	—	—	Whole body: 25 mrem/yr Critical organ: 75 mrem/yr Alternate Standards Continuous exposure: 100 mrem/yr Noncontinuous exposure: 500 mrem/yr (l)	25 mrem/yr ^(l)

^aComprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Radionuclide Reportable Quantities. The reportable quantity for radionuclides was originally set at 1 lb. The U.S. Environmental Protection Agency (EPA) recognized that this reportable quantity may not be appropriate because smaller quantities of radionuclides may present a substantial threat to public health, welfare, or the environment. As a result, EPA proposed a rule adjusting the reportable quantities for radionuclides in terms of curies rather than pounds (52 FR 8172, March 16, 1987 [EPA 1987b]). The proposed reportable quantities for ²⁴¹Am and ¹³⁷Cs are set at 0.01 Ci and 10 Ci, respectively.

^bFederal and State Drinking Water Standards—Radionuclide maximum contaminant levels (MCL). The Federal and State regulations under the Safe Drinking Water Act set forth radionuclide MCLs in 40 CFR 141.15-141.16 (EPA 1986a) and WAC 248-54-175(8) (Ecology 1983), respectively. The Federal regulations specify radionuclide MCLs for community water systems as follows:

- The MCL for combined ²²⁶Ra and ²²⁸Ra is 5 pCi/L.
- The MCL for gross alpha particle activity (including ²²⁶Ra but excluding radon and uranium) is 15 pCi/L.
- The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr.
- Except for tritium and ⁹⁰Sr, the concentration of man-made radionuclides causing 4 mrem total body or organ dose equivalent shall be calculated on the basis of a 2-L/d drinking water intake. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ shall not exceed 4 mrem/yr.

For tritium and ⁹⁰Sr, the average annual concentrations assumed to produce a total body or organ dose of 4 mrem/yr are 20,000 pCi/L and 8 pCi/L, respectively.

The State MCL for combined ²²⁶Ra and ²²⁸Ra is the same as the Federal MCL; however, the State also sets an MCL for ²²⁶Ra alone (3 pCi/L) and excludes only uranium from the MCL for gross alpha activity (15 pCi/L). The 4-mrem/yr limit upon which the MCL for beta and gamma activity is based is the same as the Federal limit. However, the State regulations state that compliance with this limit may be assumed if the average annual concentrations for gross beta activity, tritium, and ⁹⁰Sr are less than 50 pCi/L, 20,000 pCi/L, and 8 pCi/L, respectively. If both tritium and ⁹⁰Sr are present, the sum of their annual dose equivalents to bone marrow may not exceed 4 mrem/yr.

^cFederal Air Quality Standards—Air Standards for Radionuclides. The EPA's National Emission Standards for Hazardous Air Pollutants (40 CFR 61) EPA 1982 include, in Subpart H, a standard for air emissions at U.S. Department of Energy (DOE) facilities. (The Subpart does not apply to facilities regulated under 40 CFR 190, 191, or 192 [EPA 1977, 1985b, 1983]). The State of Washington has an emission standard in WAC 173-480-070 (Ecology 1986). Each standard limits the air emission of radionuclides to those amounts that cause a dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to the critical organ of any member of the public (40 CFR 61.92; WAC 173-480-040) (EPA 1982; Ecology 1986). Doses due to ²²⁰Rn, ²²²Rn, and their respective decay products are excluded from these limits.

To determine compliance with these standards, emissions shall be determined and dose equivalents shall be calculated using sampling procedures and dose conversion models that are approved by the EPA and the Washington Department of Social and Health Services. Compliance will be determined by calculating the dose to members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public may be (WAC 173-480-070) (Ecology 1986) or where any member of the public resides or abides (40 CFR 61.93) (EPA 1982).

If a facility exceeds the above values, DOE may apply for an alternate emission standard under the Federal regulations. The EPA will establish an appropriate emission standard that will ensure that no member of the public being exposed to emissions from the facility will receive a continuous exposure of more than 100-mrem/yr effective dose equivalent and a noncontinuous exposure of more than 500-mrem/yr effective dose equivalent from all sources, excluding natural background and medical procedures (40 CFR 61.97) (EPA 1982).

Because the radionuclide emission limit is given in the form of a population dose limit, a specific emission limit cannot be derived for each constituent of a radioactive material that contains more than one radionuclide. Instead, performance and risk assessments must be conducted to determine whether current or future emissions of the constituents present at the site in question will result in a total effective dose equivalent that exceeds the regulatory limits.

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Table 7-2. Potential Applicable or Relevant and Appropriate Requirements for Selected Radionuclides in the 1100 Area Operable Unit. (Sheet 2 of 3)

⁴¹⁰CFR 20 (NRC 1979)—Concentrations in Air and Water Above Natural Background. The U.S. Nuclear Regulatory Commission (NRC) regulations in 10 CFR 20 (NRC 1979) establish radiation protection standards for activities licensed by the NRC. The use of radioactive material not licensed by the NRC is not subject to these regulations; however, these regulations provide the only specific regulatory specification of emission limits for all radionuclides.

The regulations in 10 CFR 20.106 (NRC 1979) state that a licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations that exceed the limits in Appendix B, Table II of 10 CFR 20 NRC (1979). The limits apply at the boundary of the restricted area.

		<u>Concentrations in Air and Water Above Natural Background for Selected Radioisotopes (μCi/mL)</u>	
<u>Radioisotope</u>		<u>Air</u>	<u>Water</u>
²⁴¹ Am	Soluble	2.0×10^{-13}	4.0×10^{-6}
	Insoluble	4.0×10^{-12}	3.0×10^{-5}
¹³⁷ Cs	Soluble	2.0×10^{-9}	2.0×10^{-5}
	Insoluble	5.0×10^{-10}	4.0×10^{-5}

For mixtures of radionuclides in which the identities and concentrations of all constituents are known, the concentration must be limited so that the sum of the ratios of each concentration to its corresponding limit does not exceed unity. If either the identity or concentration of any radionuclide in the mixture is not known, the limiting values are 2.0×10^{-14} μCi/mL for air and 3.0×10^{-8} μCi/mL for water. Other rules are provided for cases in which some, but not all, of the constituent identities and concentrations are known. (Concentration limits are also specified for restricted areas to control occupational doses.)

^eEnvironmental Radiation Protection Standards for Radioactive Waste Management and Disposal. The EPA regulations in 40 CFR 191 (EPA 1985b) contain environmental radiation protection standards for the management and disposal of spent nuclear fuel and high-level and transuranic radioactive waste. The regulations require that during waste management, storage, and disposal the combined annual dose equivalent to any member of the public shall not exceed 25 mrem to the whole body and 75 mrem to any critical organ for facilities operated by the DOE and not regulated by the NRC (40 CFR 191.04 and 191.15 [EPA 1985b]). During the disposal period, all potential exposure pathways associated with undisturbed operation of the disposal system shall be considered, including the assumption that individuals consume 2 L/d of drinking water from any significant source of groundwater outside of the controlled area (40 CFR 191.15 [EPA 1985b]). During waste management and storage, the EPA may issue alternative standards if such standards will prevent any member of the public from receiving a continuous exposure of more than 100 mrem/yr dose equivalent and an infrequent exposure of more than 500 mrem/yr from all sources, excluding natural background and medical procedures (40 CFR 191.04 [EPA 1985b]).

The 25-mrem annual dose limit (all pathways) is repeated in the EPA regulations in 40 CFR 193 (EPA 1988b), which contain environmental standards for the management, storage, and land disposal of low-level radioactive waste. The regulations in EPA (1983), which contain health and environmental protection standards for uranium and thorium mill tailings, require that remedial actions at inactive uranium processing sites provide reasonable assurance that releases of ²²²Rn from residual radioactive material to the atmosphere will not:

- Exceed an average (over a year period) release rate of 20 pCi/m²·s
- Increase the annual average concentration of ²²²Rn in air at or above any location outside the disposal site by more than one-half picocurie per liter (40 CFR 192.02(b)) (EPA 1983).

As discussed under the radioactive air standards, the dose limit does not prescribe specific radionuclide concentration limits, and it is thus difficult to use it in setting cleanup standards for individual constituents.

The disposal standards in EPA (1985b) require that, in addition to the dose limits described above, the cumulative releases of radionuclides to the accessible environment for 10,000 yr after disposal shall have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table I (Appendix A to 40 CFR 191) and a likelihood of less than one chance in 1,000 of exceeding 10 times those quantities (EPA 1983). The limits in Table I are given per unit of waste, which may be a specified amount of spent nuclear fuel, high-level waste, or any of the following:

- Each 100 million Ci of gamma- or beta-emitting radionuclides with half-lives greater than 20 yr but less than 100 yr
- Each 1 million Ci of other radionuclides (i.e., gamma- or beta-emitters with half-lives greater than 100 yr or alpha-emitters with half-lives greater than 20 yr)
- An amount of transuranic wastes containing 1 million Ci of alpha-emitting transuranic radionuclides with half-lives greater than 20 yr.

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Table 7-2. Potential Applicable or Relevant and Appropriate Requirements for Selected Radionuclides in the 1100 Area Operable Unit. (Sheet 3 of 3)

Release limits are given for a number of radionuclides. The limits for ^{241}Am and ^{137}Cs are 100 and 1,000 Ci per unit of waste, respectively. Caution should be exercised in using these values, however. The specification of limits on both total dose and radionuclide emissions has been a source of confusion, since it is not clear that complying with the latter requirement results in complying with the former. The (EPA 1985b) regulations have been invalidated by the courts and remanded back to the EPA on groundwater protection issues, and it is possible that, during the revision of the groundwater protection standards, the release limits may be deleted from the regulations.

The groundwater protection standards of (EPA 1985b) require that the disposal system not cause the radionuclide concentrations averaged over any year in water withdrawn from any portion of a special source of groundwater to exceed the following limits:

- 5 pCi/L of ^{226}Ra and ^{228}Ra
- 15 pCi/L of alpha-emitting radionuclides (including ^{226}Ra and ^{228}Ra but excluding radon)
- The combined concentrations of radionuclides that emit either beta or gamma radiation that would produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr if an individual consumed 2 L/d of drinking water from such a source of groundwater [40 CFR 191.16(a)] (EPA 1985B).

These standards were vacated and remanded back to EPA for further review. The court ruled that the EPA had not adequately explained or reconciled the difference between the 25-mrem/yr individual dose limit for all pathways and the 4-mrem/yr limit for the drinking water pathway that forms the basis for the MCLs under the Safe Drinking Water Act.

¹Under Subpart H of 40 CFR 61 (EPA 1982) (Clean Air Act regulations), air emissions of radionuclides from DOE facilities shall not exceed those amounts that cause a dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to the critical organ of any member of the public.

⁹This is a State maximum contaminant level. Both WAC 248-54-175 (Ecology 1983) and 40 CFR 141.16 (EPA 1986a) set forth a standard for gross beta particle radioactivity as follows: the average annual concentration of beta particle radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr. The concentration of <50 pCi/L is the average annual concentration assumed to produce an annual total body or internal organ dose of 4 mrem.

^hValues are given for individual plutonium isotopes.

ⁱThe standards for both 40 CFR 191 and 40 CFR 193 (EPA 1985b and 1988b) are for all potential exposure pathways.

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7.1.2 Development of Standards Where No Applicable or Relevant and Appropriate Requirements Exist

When specific numerical standards, as obtained from ARARs, are not available for the chemicals of interest, development of additional chemical-specific standards to be used in evaluating remediation technology options and selecting cleanup objectives is necessary. Both the ARARs and these additional standards are then used to develop numerical performance goals for remedial alternatives.

The development of standards in the absence of ARARs is described as part of RCRA guidance for concentration limits for groundwater protection. Alternate standards or criteria are applied when the maximum contaminant level or health-based standard is not appropriate for the specific conditions of a site. These standards or criteria provide flexibility in cleanup actions by taking into account the specific factors of each site. The same chemical, for instance, may have different target levels for cleanup at different sites, depending on site location and the characteristics of the waste and site.

Where ARARs do not exist, the EPA has allowed some flexibility in the application of alternative standards. For example, where the aquifer of concern may be used for drinking water, the cleanup limit could be set on the basis of what would be safe to drink. Alternatively, the limit could be set based on access to the groundwater source and the potential of exposure to populations. If consumption of the groundwater could be restricted by the use of institutional controls or if the aquifer were clearly unsuitable for use as drinking water, the cleanup limit could be set without regard to drinking water considerations or at a level that takes account of controls at the point of use.

The development of numerical standards in the absence of ARARs is based on an assessment of the health risks presented by the chemicals at a site. Cleanup levels identified through this method must account for risks posed by both carcinogens and noncarcinogens, although in practice the carcinogenic risk often drives the design process for remedial alternatives. An allowable health or environmental exposure level must be determined for each constituent. The appropriate level will be dependent on the most vulnerable human or environmental receptor near the facility.

For carcinogenic effects, ambient chemical concentration levels should be selected consistent with a risk range of 1×10^{-4} to 1×10^{-7} . However, in practice the health-based standards are usually set using a target carcinogenic risk of 1×10^{-6} . For noncarcinogenic effects, a hazard index is developed to identify the contaminants of most concern. At sites where both potential carcinogens and noncarcinogens are involved, the potential carcinogens will generally drive the design process; however, during the detailed analysis of alternatives, designs must be reevaluated to ensure that noncarcinogenic risk is reduced to acceptable levels.

The EPA guidance documents do not contain specific instructions on developing standards for radionuclides. In general, a dose limit of 25 mrem/yr (all pathways) has been set in EPA and U.S. Nuclear Regulatory

Commission (NRC) regulations for nuclear power operations and waste disposal (e.g., 40 CFR 191 [EPA 1985b], 40 CFR 193 [EPA 1988b]) and could be used to develop radionuclide-specific standards.

If more than one carcinogen exists at a site and/or more than one route of exposure is possible, the carcinogenic exposure must be apportioned among the multiple carcinogens and exposure routes to develop target concentrations for each chemical. One method of apportionment is to divide a target carcinogenic risk level by the number of potential carcinogens, while another is to let one or two "bad actor" chemicals drive the design process. The specific apportionment strategy must be determined on a site-by-site basis. The risk must also be apportioned among routes of exposure if exposure to a chemical for a population occurs by more than one route.

The purpose of considering standards for cleanup, whether mandated through ARARs or developed by using alternative criteria where ARARs do not exist, is to ensure that the technology selected for remediating a site will provide the appropriate level of health and environmental protection to the public and the surrounding environment. Health-risk-based assessments are required for developing adequate standards for remediation technologies where ARARs do not exist. These standards can then be used to evaluate the effectiveness of technology alternatives for remedying a waste site.

7.1.3 Remedial Action Objectives

Before the actual cleanup of a site can be initiated, the remedial action alternatives and the associated technologies must be selected. The development of remedial action objectives to guide that process is a required step in the selection of remediation technology alternatives. Remedial action objectives consist of medium-specific (i.e., groundwater, soil, surface water, and air) or operable unit-specific objectives for protecting human health and the environment. These objectives should be specific enough to narrow the range of alternative remediation actions to be considered, but should not unduly limit the alternatives. Cleanup standards are one example of remedial action objectives (i.e., one objective may be to meet the maximum contaminant levels of the Safe Drinking Water Act). Another example is an objective to treat and dispose of wastes onsite to avoid transporting waste offsite.

To develop the objectives, site-specific information is required on the contaminants, media, exposure pathways, and remediation goals for a particular site. This information permits a range of treatment and containment alternatives for that site to be specified. Remedial action objectives for protecting human health and the environment should consider the following:

- The contaminant(s) of concern
- Exposure route(s) and receptor(s)
- An acceptable contaminant level or range of levels for each exposure route.

Remedial action objectives are designed to protect human receptors as well as environmental receptors. While the term "human receptors" is specific, the term "environmental receptors" is broad and includes plants and animals as well as soil, air, and water. Objectives intended to protect human receptors should include a target contaminant level and an exposure route, while those intended to protect environmental receptors should include a target cleanup level and the medium of interest.

In general, the contaminant levels that will result in acceptable exposure to humans are better defined than the target cleanup levels for protecting the environment, which are often site-specific and subject to interpretation as well as negotiation with the appropriate regulating agencies. For example, the maximum contaminant levels under the Safe Drinking Water Act of 1974 are health-based limits that must be met for any water that is used for human consumption, whereas cleanup standards that will be applied to an aquifer that is not currently being used for drinking water and does not have the potential for future use may be subject to site-specific negotiations.

Acceptable exposure levels for protection of human health should be based on known and available risk factors and contaminant-specific ARARs, such as those provided in Section 7.1.1. Contaminant levels in each medium should be compared with the acceptable levels to determine where human health is not being protected. Thus, specific cleanup objectives can be developed.

Realistic cleanup objectives for the 1100-EM-1 operable unit cannot be established until the levels and extent of contamination are determined through the RI process.

7.1.4 Point of Applicability of Applicable or Relevant and Appropriate Requirements

Once the RA objectives have been determined and the potential ARARs identified, there must be identification of where compliance with the ARARs will be measured at the site. The points of applicability are at the boundaries that will be used to assess the effectiveness of the alternative technologies. Because the RA objectives and cleanup standards are developed for each medium of interest (i.e., groundwater, soil, surface water, and air), specific, discrete points of applicability for the ARARs must be considered. For example, applicability should be considered at the following locations:

- Groundwater, immediately below the edge of the zone of remedied waste near the groundwater/unsaturated zone interface
- Soil, at the edge of the remedied waste zone
- Surface soil, at the location of waste treatment.

In addition, the effectiveness of different technologies may need to be evaluated at specific points of compliance with consideration of the technology/environment interface. For example, if incineration is used, one point of applicability may be established for emissions to the environment

from a stack. The stack emissions are not subject to the specific cleanup standards for the site that is being remedied; however, these emissions are regulated and must meet a given set of standards and requirements.

Many of the standards associated with environmental protection statutes and regulations, such as the Clean Air and Water Acts (1977), generally apply at the end of the stack or pipe. However, RCRA (1976), CERCLA (1980), and their implementing regulations do not clearly define the point of applicability for testing compliance.

The CERCLA (1980) and its implementing regulations (40 CFR 300 and 302 [EPA 1985f and 1985a, respectively]) do not provide guidance as to whether groundwater cleanup levels must be met throughout a site or must be met only at the site boundary. In addition, neither CERCLA (1980) nor SARA (1986) defines "site boundary." The SARA (1986) states that the boundary of the facility will be defined at the conclusion of the RI/FS. Facility, as used in the definition, refers to the operable waste unit.

The RCRA (1976) and its implementing regulations (40 CFR 264 and 265 [EPA 1980b and 1980a, respectively]) state that the point of compliance for applying the groundwater protection standard and conducting monitoring is specified by EPA. According to 40 CFR 264 (1980b), the point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the site. The RCRA regulations (40 CFR 264.95 [EPA 1980b]) define the waste management area as "the limit projected in the horizontal plane of the area on which waste is placed." This means the area occupied by the waste and any area contaminated by subsequent waste migration. If the site or operable unit contains more than one site, the waste management area is described by an imaginary line circumscribing the sites. Thus, the applicable standard or criterion must be met at the boundary of the "waste management area."

Because the source of contamination (the waste site) can be identified through sampling efforts, the points of applicability for compliance testing can be defined. However, contaminated-soil standards are not clearly defined in the regulations; thus, they will be subject to negotiation with the regulating agencies. While standards for groundwater protection are readily available in the regulations and guidance, the point of applicability for compliance testing of groundwater cleanup is much more difficult to define because it must be based on the hydrogeologic conditions at a particular waste site. Until the hydrogeology of a particular waste site is understood, the point at which the cleanup standards are applicable cannot be readily determined.

The EPA has published proposed guidelines that must be considered in determining standards and points of applicability for groundwater cleanup and compliance testing. The guidelines establish a procedure for classifying groundwater within a prescribed area around a facility or activity based on the value, use, and vulnerability to contamination of the groundwater. The

three classifications of groundwater, which may afford different levels of protection, are described as follows:

Class I Special groundwaters (unusually high value)

Class II Current and potential sources of drinking water and water having other beneficial uses

Class III Groundwater that is not a potential source of drinking water and is of limited potential use.

The proposed guidelines will establish a procedure for classifying groundwater site by site, rather than by region or aquifer. For a facility or activity that may affect the underlying groundwater, a "classification review area" would be established for the area within a 2-mi radius of the facility or activity. The area could be expanded or reduced on the basis of the prevailing hydrogeological conditions.

The EPA's groundwater-classification system may become a factor in determining the level of protection or remediation for CERCLA and RCRA sites. Because the EPA has estimated that 83% to 94% of classification determinations will result in Class II designations (current and potential sources of drinking water), drinking water standards may be assumed to apply to the 1100-EM-1 operable unit.

In addition, EPA and NRC have established regulations that are not as restrictive as the RCRA regulations. The Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Waste regulations in 40 CFR 191 (EPA 1985b) and the Licensing Requirements for Land Disposal of Radioactive Wastes regulations in 40 CFR 61 (EPA 1982) permit a horizontal and vertical "buffer zone" between a contaminant source and the compliance point. This concept should be examined and its relevance to remediation activities determined as contrasted with the more restrictive EPA requirements.

7.2 ANALYSIS OF ALTERNATIVES

This section contains descriptions of the required analyses of the no-action alternative, containment alternatives, and treatment alternatives. These analyses are required to support the selection of an alternative for the 1100-EM-1 operable unit.

7.2.1 Analysis of No-Action Alternative (Phase I, Feasibility Study)

Analysis of the no-action alternative constitutes the first step in the risk assessment process. The purpose of the analysis of the no-action alternative is to determine the necessity for RA, thus providing justification for proceeding with the RI/FS or closing the site with no remedial action. If RA is deemed necessary, the results of the analysis of the no-action alternative will provide a baseline for future risk assessments as well as guidance for site characterization activities. If RA is not

necessary, the results of the analysis of the no-action alternative will be reviewed, verified, and incorporated into an endangerment assessment.

All activities conducted as part of the RI/FS process must contribute to compliance with applicable regulations. Release of contaminants to the environment is governed by a number of regulations. These regulations determine performance objectives for risk assessments. Specific performance objectives will be included in the list of ARARs. The following statutes, DOE orders, and regulations will be considered during the development of ARARs and cleanup objectives (see Sections 7.1.1 to 7.1.4):

- Federal (1977) and State of Washington (1961) Clean Air Acts
- CERCLA (1980), as amended by SARA (1986)
- RCRA (1976)
- DOE Orders 5820.2A and 5400.1 (DOE 1984 and 1988, respectively)
- Federal Water Pollution Control Act (Clean Water Act [1977])
- National Environmental Policy Act (1970)
- Safe Drinking Water Act (1974)
- Toxic Substances Control Act (1976)
- State of Washington Hazardous Waste Management Act (1976)
- Washington State Environmental Policy Act (1984).

Performance objectives will appear in different forms, depending on the contaminant considered and the regulation being quoted. Expected types of performance objectives include maximum contaminant levels, reportable quantities, health effects, carcinogenic potency factors, reference dose, and annual dose equivalents (dose calculations are expected to require minimal effort for the 1100 Area). The output required from risk assessment models to address performance objectives depends on the specification of ARARs (see Sections 7.1.1 through 7.1.4). One of the criteria for selection of risk assessment models will be the type of output produced. Therefore, identification of comprehensive ARARs as early as possible in the RI/FS process is critical.

7.2.1.1 Risk Assessments and Sensitivity Analyses. Risk assessments and sensitivity analyses are necessary throughout the RI/FS process. In the scope-determination and site-characterization phases, risk assessments and sensitivity analyses provide an analytical basis for prioritizing data needs and preliminary estimates of the need for remedial actions. During the feasibility study phase, risk assessments and sensitivity analyses provide a basis for screening and ranking disposal alternatives (e.g., no-action, containment, treatment, and no long-term management of residuals).

The scope of a risk assessment is discussed in the Draft Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA

1988a). Analysis of the no-action alternative is described as a baseline risk assessment in Section 3.4.2 of EPA (1988a, pp. 3-35 to 3-43). Application of risk assessments during screening of alternatives is discussed in Section 5.2.2.1 of EPA (1988a, pp. 5-10). Specific CERCLA requirements, statutory considerations, and evaluation criteria for analysis of alternatives are discussed in Section 7.1.1 of EPA (1988a, pp. 7-1 to 7-3). A description of the process for a detailed analysis of alternatives is provided in Section 7.2 of EPA (1988a, pp. 7-4 to 7-35). Detailed guidance for the conduct of individual aspects of a risk assessment is provided in the Superfund Public Health Evaluation Manual (EPA 1986b) and the Superfund Exposure Assessment Manual (EPA 1988c).

The analysis of the no-action alternative, as well as detailed analysis of alternatives (see Sections 7.4.4 through 7.4.6) will address the following nine evaluation criteria identified in Section 7.2.2 of EPA (1988a, pp. 7-7 to 7-11):

- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume
- Implementability
- Cost
- Compliance with ARARs
- Overall protection
- State acceptance
- Community acceptance.

7.2.1.2 Computer Models. Computer models will be used to assess the relative effectiveness of each disposal alternative (including the no-action alternative) with respect to the nine criteria and applicable ARARs (performance objectives). A list of available models and a comparison of the relative merits of each model are provided in Appendix E. More comprehensive lists of available codes for each pathway are provided in EPA (1988c). The plans for development of specialized computer codes for Hanford Site applications are provided in Davis (1988). Two types of models will be evaluated during the analysis of the no-action alternative. For the purposes of this work plan, the two types of models will be categorized as integrated or specialized.

Integrated models are capable of representing all or most of the credible pathways (i.e., groundwater, direct exposure, biotic, air, and surface water) for potential exposure to disposed organic and inorganic (including radioactive) wastes. The advantages of integrated models are that they are easy and inexpensive to apply, the results can be obtained in a relatively short period of time, and the cost of code maintenance can be reduced (i.e., only one code versus several codes).

As opposed to integrated models, specialized models can typically only represent individual elements of the system to be modeled. In some cases, multiple specialized codes will be required to analyze an individual pathway (e.g., groundwater). The advantages of specialized models include a greater defensibility of results and the ability to obtain a more detailed understanding of transport processes and critical parameters along each pathway (i.e., avoid problems associated with a "black box" approach).

The lack of sufficient site-specific groundwater and soils data precludes the extensive use of specialized models for the analysis of the no-action alternative (i.e., the quantity and quality of available data determine the level of modeling sophistication that is justified). Thus, the initial analysis of the no-action alternative will examine conservative, simplified representations of the actual system. As site characterization data are obtained, more sophisticated models can be justified for the detailed analysis of alternatives including the no-action alternative.

The approach for a risk assessment will be to start with simple models consistent with the quantity of data available. These simple models will provide conservative estimates of the risk associated with the operable unit. If the conservative estimate indicates that the risk is acceptable in accordance with applicable regulations, then further analysis will not be necessary. Prior to concluding that further analysis is not necessary, an independent peer review of the results will be conducted to confirm the results. However, if the conservative predictions indicate that the risk related to a given remedial action is unacceptable, then more data will have to be collected and more rigorous models may also be used to reduce the conservatism of the analysis. An alternative to collecting more data and using better models would be to eliminate the remedial alternative from consideration.

7.2.1.2.1 Integrated Models. Three integrated models will be considered during the baseline risk assessment and sensitivity analyses of the 1100-EM-1 operable unit. The three models to be considered include (listed alphabetically): GEMS (GSC 1982), PATHRAE (Rogers and Hung 1987), and RAPS/MEPAS (Whelan et al. 1986, 1987). These models are capable of computing health effects resulting from organic and inorganic (including radioactive) contaminants through the air, biotic, direct contact, groundwater, and surface water pathways. Use of these models for the analysis of the no-action alternative will provide the opportunity to evaluate the relative merits of each model. An indication of the applicability of the integrated models for the analysis of alternatives will also be obtained.

7.2.1.2.2 Groundwater Pathway Models. The groundwater pathway may require the use of specialized models due to the close proximity of the 1100 Area to Richland water supply wells. The need for specialized models will be assessed through the use of relatively simple models. Several different specialized models for the groundwater pathway are available. Groundwater transport models that will be considered, include: VAM2D/SATURN (Huyakorn et al. 1984, 1985, 1987), PORFLO (Kline et al. 1983, unsaturated capabilities currently being incorporated), and MAGNUM/CHAI NT (England et al. 1985; Kline et al. 1985). An additional model that will be considered is RITZ (Nofziger and Williams 1988). The RITZ model has been applied by the EPA to model

vadose zone transport in oily environments in the past. One or more of these specialized models may be used as a primary model or to confirm the results of simplified models in order to provide a defensible set of results.

Models capable of representing multiple fluid phases (or densities) may be necessary for risk assessments of the 1100 Area. Multiphase codes are state of the art and thus are at various stages of development. Two codes, SWANFLOW (developed by GeoTrans, Inc.) and MOFAT-2D (developed at Virginia Polytechnic Institute) are being considered. The capabilities of these codes and utility of obtaining a multiphase code for risk assessments of the 1100 Area and future sites will be examined during the analysis of the no-action alternative.

7.2.1.2.3 Air, Biotic, Direct Contact, and Surface Water Transport Pathways. Specialized models to estimate health effects due to transport through air, biotic, direct contact, and surface water pathways are not expected to be necessary for 1100 Area risk assessments. The modules for these pathways in the GEMS, PATHRAE, and RAPS/MEPAS integrated models are expected to be sufficient based on current understanding of site conditions.

7.2.1.3 Analysis of Exposure Levels. The potential for human exposure to wastes disposed of in the 1100 Area will be assessed using the computer models described above. A combination of integrated and specialized models are expected to be used for the analysis of the no-action alternative. The air, biotic, direct contact, groundwater, and surface-water pathways will be considered to determine potential exposure levels. The analysis will also consider the sensitivity of predicted human exposure to variations in input parameter values. This will provide information on the relative importance of parameters to guide site-characterization activities, as well as the necessary information for comparison of exposure predictions with ARARs and evaluation of health risk.

7.2.1.4 Comparison with Applicability of Applicable or Relevant and Appropriate Requirements. The ARARs and other appropriate standards will determine the necessary form of the results from the computer models (i.e., contaminant concentrations, cumulative dose, etc.). In this respect, a direct comparison between model predictions and ARARs will be possible once the point of application is determined.

7.2.1.5 Evaluation of Health Risk. Evaluation of health risk for the analysis of the no-action alternative will be obtained with the GEMS, PATHRAE, or RAPS/MEPAS integrated computer codes. Health risk will be determined by integrating the risks predicted in the exposure assessment due to carcinogenic, noncarcinogenic, and environmental factors. The results of sensitivity analyses will provide an indication of the uncertainty associated with the predictions.

7.2.2 Analysis of Containment Alternative

The EPA (1988a) states that "one or more alternatives that involve containment of waste with little or no treatment, but protect human health and the environment by preventing potential exposure and/or by reducing the mobility" should be developed "to the extent practicable" to control the

waste source. Containment, in this context, is viewed as an action that neither destroys nor removes the contaminants of concern, but prevents or significantly slows the spread of contamination from the source through the use of barriers.

Containment technologies are usually viewed as temporary solutions, owing to their frequent use of materials and designs that lose their effectiveness with time. As such, EPA shows a preference for solutions "that permanently and significantly reduce the volume, toxicity, or mobility of hazardous substances, pollutants, and contaminants as its principal element." Thus, containment alternatives that offer permanent solutions (i.e., no maintenance required) will receive the highest consideration in the 1100-EM-1 operable unit RI/FS process.

To provide a permanent solution to waste source problems at the 1100-EM-1 operable unit, containment may be a part of an overall remedial strategy that also includes excavation, treatment, and/or imposition of institutional controls. For example, an overall remedial strategy may involve in situ flushing of mobile contaminants from the contaminated soils, followed by the installation of a suitable hydrologic barrier, and finally the emplacement of markers to identify the presence of hazardous materials below.

Another option involving containment is the removal of contaminated waste and soils and containment of the removed material in a RCRA landfill or a greater confinement disposal facility located within the operable unit. Note that, at present, RCRA requirements for containment of hazardous wastes do not apply to 1100 Area CERCLA wastes kept within the operable units, nor are those RCRA requirements considered sufficient to ensure a permanent solution. However, if an imminent risk to drinking water supplies at the north Richland well field is discovered through the RI process, a decision could be made to expeditiously exhume and emplace the contaminated source material in a facility similar to a RCRA Subtitle C landfill while studies on a permanent solution are conducted. Although RCRA and Washington State requirements for hazardous waste storage facilities would not apply in this case (in particular the permit requirements), many of the technical requirements of such facilities should be considered and met if judged important to ensuring that a temporary storage facility can be safely operated while a permanent solution is being developed.

7.2.2.1 Identification of Containment Technology. There are two types of containment alternatives that could be applied to the 1100-EM-1 operable unit if remediation is demonstrated to be required.

- **In Situ Containment.** In this case, barriers would be placed over and perhaps around the waste source in its current location after possible treatment (for example, in situ flushing to remove highly mobile contaminants).
- **Postremoval Onsite Containment.** In this case the waste source would be exhumed, treated (if necessary), and entombed in a greater confinement disposal facility or RCRA-like facility.

Guidance on design, construction, and maintenance of cover systems for hazardous waste is given in EPA (1987c). The general cover design identified in this document consists of two or more layers of soils and other materials. The document also provides guidance on "methods of maintenance and repair over the unusually long life of a solid waste disposal facility." As such, the nonpermanent design concepts identified therein will only be considered for temporary containment purposes, if required.

One cover concept that potentially promises 10,000 yr of effective performance is under development as part of a system for the disposal of single-shell tank wastes, transuranic-contaminated solid waste sites, and pre-1970 buried suspect transuranic-contaminated solid waste within the 200 Areas. The concept, which includes surface barriers and markers, is included as part of the reference alternative in the ROD for the Final Environmental Impact Statement (FEIS), Disposal of Hanford Defense High-Level Transuranic and Tank Wastes (DOE 1987a). Although wastes in the 1100 Area do not fall under any of the FEIS waste classifications, the concept may be applicable to those wastes.

This technology, which is being developed through a long-term program conducted by Westinghouse Hanford and PNL, may be directly applicable to the 1100-EM-1 operable unit as it is being designed for essentially identical physical conditions but much more hazardous wastes. Because completion of the technology may occur after it is needed for the 1100-EM-1 operable unit, a suitable short-term barrier (e.g., a sloped geomembrane liner overlain with soil on which native grasses are planted) may be required as an interim measure.

A less elaborate cover system (e.g., backfill with soil) may suffice where the hazard is low. The acceptability of cover systems and other systems built to contain exhumed waste must be shown through performance analyses described in Section 7.2.2.2.

Greater confinement disposal facilities for exhumed or new waste are being designed by a number of DOE contractors and commercial interests. For example, Oak Ridge National Laboratory recently announced a "tumulus" design in which wastes are encapsulated in concrete blocks that are subsequently emplaced in an at-grade, concrete-walled facility. Later, layers of gravel and soil are piled over the concrete facility to provide further protection. The design is based on a French concept for storage of low-level radioactive waste.

A disposal system for liquid low-level waste that is under development at the Hanford Site may also be adaptable to 1100 Area waste disposal. The Hanford Site disposal system includes concrete vaults that are designed to accept liquid grouts that subsequently harden into monolithic blocks. The subsurface concrete vaults feature double liners and leachate-collection systems. Should a decision be made to exhume and temporarily store bulk waste and contaminated soil while completing development of a permanent remedial solution, some of the features of such a hazardous waste storage facility might be employed in a temporary storage facility, particularly the liner and leachate-collection system. Covering the waste with plastic or a temporary building to contain volatile organics and prevent wind dispersion may also be necessary.

7.2.2.2 Evaluation of Containment Alternatives. As part of the RI/FS process, containment alternatives for the 1100-EM-1 operable unit will be compared to treatment alternatives and to the no-action alternative. The comparison will be based on cost and reduction of risk, particularly with respect to ability to meet ARARs and associated cleanup objectives as described in Section 7.1. Since containment alternatives are usually less costly than treatment options (because of comparatively fewer handling requirements), containment alternatives could have an advantage if they can be shown to be capable of meeting ARARs and to be permanent. These determinations can only be made through the use of predictive models and performance tests. Performance tests are conducted to provide the input required to run predictive models. Performance tests may also be required in the event of the need for a temporary barrier (e.g., to contain exhumed waste) to demonstrate chemical compatibility of the containment material with the exhumed waste.

The predictive models used in the evaluation of containment alternatives will, in many cases, be the same as those used to evaluate the no-action and treatment alternatives. A discussion of the use of predictive models (performance assessment methodology) for the no-action alternative is given in Section 7.2.1. Each containment alternative will require these models as well as its own unique set of models that are capable of predicting the effectiveness of the containment system. The containment-specific models predict migration rates of contaminants from the containment system.

Once a contaminant migrates outside of the containment zone, most of the same pathway and dose models used in the no-action alternative can be used to predict environmental and human risk. Ongoing performance assessment programs at Westinghouse Hanford and PNL are developing these more generic pathway and dose models. Other Hanford Site programs developing predictive models include the barriers program and the grout program. The barriers program is developing models and data specifically for the FEIS surface barrier previously described. The grout program is developing unsaturated zone models for predicting water flow around subsurface vaults. Other models will be required to predict containment effectiveness. These models and data must be developed and applied to the 1100-EM-1 operable unit through the RI/FS process to enable comparison of containment alternatives with the other alternatives.

Integration of RI/FS activities with those of the other programs developing models and data will be necessary to ensure that the overall needs of this effort are met. Specific data needs of this effort depend to a large degree on the design of the containment system. For example, if the FEIS barrier design is to be used over an 1100 Area waste site (e.g., the Paint and Solvent Disposal Site [1100-2]), the degree of potential subsidence must be known to predict the effectiveness of an overlying barrier. Subsidence control methods are being developed at the Hanford Site by Westinghouse Hanford (Phillips et al. 1981) and are an important aspect of ensuring the success of the FEIS barrier. Subsidence control development needs are also identified in the Hanford Waste Management Technology Plan (DOE 1987b).

The barriers program, which is developing the FEIS barrier, is divided into the following 11 groups of tasks:

- Biointrusion control
- Water infiltration control
- Erosion control
- Physical stability
- Human interference control
- Selection of construction materials
- Field monitoring and model validation
- Natural analog inferences
- Long-term climate change effects
- Design issues
- Documentation issues.

Investigation of the effects of these parameters is being carried out through various studies, including laboratory and field performance tests. These tests are similar in scope to treatability tests required by the RI/FS process to evaluate waste treatment options. As such, the barriers program is generating the type of information required to compare the FEIS containment alternative to the no-action and treatment alternatives. However, the time needed to complete development of this containment alternative may exceed the time at which the barrier is needed for the 1100-EM-1 operable unit. Sufficient information to evaluate this alternative may not be available in time to materially aid in selecting an alternative for the 1100-EM-1 operable unit. This may not be an issue if it can be shown that the 1100-EM-1 operable unit does not pose a near-term risk as a result of conducting site characterization and risk assessments. Thus, delaying the ROD for the 1100-EM-1 operable unit while development of the barrier technology continues may be possible. Alternatively, an effective short-term barrier system for interim use over the waste can probably be developed and designed in a matter of months. This barrier would provide the necessary protection until the permanent barrier is ready for implementation.

7.2.3 Analysis of Remedial Action Alternatives

7.2.3.1 Contaminants. Because of the types of activities conducted at the 1100-EM-1 operable unit, a number of potential contaminants have been identified. These contaminants were grouped as shown in Table 7-3. These groupings were developed because they are related to the types of treatment technologies that could be employed.

The first group is heavy metals. In general, SARA guidance shows a preference for destruction of the waste, which renders the waste harmless. Heavy metals cannot be destroyed but they can be physically and/or chemically altered so that they no longer pose an environmental concern. This may entail reacting the heavy metals with other species so as to create a physical form with low leachability. Heavy metals can also be chemically altered to reduce their solubilities.

Table 7-3. Contaminants Grouped for
Appropriate Remedial Actions.

A. Heavy metals	Mercury Chromium Arsenic Lead
B. Potentially toxic or undesirable anions	Nitrates Sulfates
C. Aromatic hydrocarbons	Chlorinated Polychlorinated biphenyl
	Nonchlorinated Benzene Toluene Xylene Di-n-octyl phthalate Bis (2-ethylhexyl) phthalate
D. Halogenated aliphatic hydrocarbons (solvents)	Methylene chloride Carbon tetrachloride Trichloroethylene Trichloroethane 1,1,1 Trichloroethane Perchloroethylene
E. Radioactive species	Radioactive species can generally be treated as cations or anions as in Groups A and B above

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Toxic anions are the second group of hazardous waste that may be present. These include nitrates and sulfates. These types of compounds are susceptible to biological reduction in a facultative anaerobic environment. In the reduced state, nitrates are converted to harmless nitrogen gas. There are also physical treatment processes, specifically anion exchange, capable of removing these wastes from an aqueous stream and concentrating the wastes for subsequent destruction, stabilization, or containment.

A third group of hazardous wastes potentially present at the operable unit is aromatic hydrocarbons. A number of physical treatment processes are capable of concentrating aromatic hydrocarbons. The most commonly applied process uses activated carbon. In addition, a range of treatment technologies are available for destroying these wastes. These technologies can be grouped into three broad categories: aerobic/anaerobic biological destruction; chemical oxidation; and thermal destruction. For the 1100-EM-1 operable unit, both nonchlorinated and chlorinated aromatics have been grouped together. This grouping was made because most technologies that would apply to one subgroup (e.g., chlorinated aromatics) would also apply to the other subgroup. Chemical and thermal destruction processes would be operated at a more intensive level for chlorinated organics but would employ very similar equipment. Biological processes would likely be generically the same (e.g., employ activated sludge), but the primary organisms that destroy the waste would likely be different.

The fourth group is halogenated aliphatic hydrocarbons (solvents). This group includes commonly used degreasers such as carbon tetrachloride and its substitutes, such as trichloroethylene. Treatment technologies applicable for the remediation of aromatic hydrocarbons will also be useful for halogenated aliphatics. However, because the wastes display very different chemical and physical characteristics, optimum process operating conditions will be very different. The aliphatics are significantly more volatile; thus, they are also candidates for the applications of such processes as air or steam stripping. Because aromatics are much less volatile, a significant amount of heat would be required for the application of these processes for the removal of aromatics from an aqueous stream. Even when the treatment process is the same, loading rates, flux rates, and detention times vary widely for the two groups of compounds.

The fifth group is radioactive species. In general, processes that apply to heavy metals and toxic anions are applicable to radioactive species. However, because the process containment requirements for radioactive materials are so constraining, the presence of radioactive materials at the 1100-EM-1 operable unit could complicate cleanup actions. By imposing longer-term design requirements for any disposal configuration (up to 10,000 yr), this could require use of the barrier terminology being developed.

7.2.3.2 Development of Treatment Alternatives--General. The objective of developing remedial alternatives is to "provide a range of waste management options" for evaluation (EPA 1988a). This range of options includes destruction of the hazardous waste, reduction of concentration of the waste to acceptable levels, and prevention of exposure to the human population. Development of each remedial alternative may entail coupling of one or more of the above options. In general, SARA guidance places a greater emphasis on technologies that destroy or significantly treat the waste. The rationale for this emphasis is that these strategies permanently reduce or eliminate the risk to human health or the environment, while containment strategies may require long-term maintenance for acceptable risk reduction. Selection of the final suite of remedies will be based on site-specific conditions, including contamination levels. The data necessary to initiate the screening and final selection processes will be developed during the Phase 1 and 2 RI as described in the SAP.

7.2.3.3 Contaminant Setting. A description of the individual sites in the 1100-EM-1 operable unit can be found in Section 4.1. Appendix A provides a discussion of the geology, hydrogeology, and other pertinent characteristics of the 1100 Area. However, very little site-specific information is available, and much of the discussion is derived from regional studies or based on extrapolation from adjacent areas. No reliable information regarding waste disposal history is available. The conceptual model presented in Section 4.1.5 is based largely on assumptions regarding site characteristics and waste disposal practices and should be considered preliminary.

For the purposes of initial planning, contaminants are assumed to exist in the soil column (vadose zone) and in the groundwater of the unconfined aquifer. The possibility of buried containers of waste also exists at the Horn Rapids landfill, 1100-2, and 1100-3 sites. Because the sites are

covered with soil and have been inactive for a number of years, remediation of air quality is not considered likely. Because no surface-water bodies or ephemeral streams are present in the immediate vicinity of the sites, surface waste remediation is also considered unlikely. Therefore, the feasibility study will primarily address remediation of contaminated soil and/or groundwater. However, the extent of remediation if any, that will be required is not known. Furthermore, different remedial alternatives may be required for each medium at each site. The following discussion is intended to identify potential remediation technologies that may be appropriate, given the limited data presently available.

7.2.3.4 Treatment Technologies. Treatment technologies can be grouped under four categories: biological treatment, chemical treatment, physical treatment, and thermal treatment. Each of these categories can be subdivided in terms of in situ, onsite, and offsite application of the treatment. The need for pretreatment of the waste and posttreatment of any secondary waste streams are other factors that may be used to further categorize treatment technologies. Many pretreatment and some posttreatment processes fall under the physical treatment category. However, in some cases, biological and chemical treatment processes might be applied for pretreatment or posttreatment.

Many contaminant removal processes (typically physical treatment processes) will require posttreatment. Air or steam stripping will remove volatile contaminants from an aqueous stream but will produce a contaminated offgas. Except under unusual conditions, the offgas will require treatment. In this example, the offgas may be passed through an activated carbon bed to adsorb the volatile organics. The spent carbon will then need to be disposed or thermally treated to regenerate the carbon and recover or destroy the organics.

Processes that either reduce or destroy the waste are shown preference under SARA guidance. Technologies that eliminate or reduce long-term reintroduction of the waste to the environment and the threat to human health are to receive higher priority. These higher priority technologies include chemical oxidation or reduction of the hazardous waste. Chemical oxidation may be accomplished by the application of biological, thermal, or chemical (including photo-oxidative) processes. In some cases, the waste characteristics are such that only the most intensive processes are effective. This is particularly true for cleavage of the carbon-chlorine bond in polyvinyl-chlorides and many solvents, both of which are potentially present at the 1100-EM-1 operable unit. Cleavage of this bond, for example, requires temperatures in excess of 2200 °F to 2400 °F and relatively long residence times, if thermal processing is to be performed at ambient pressures. This requirement eliminates many conventional incineration processes from consideration. More intensive thermal processes such as plasma-arc incineration and cement-kiln combustion are required.

A matrix approach was applied to identify potentially applicable (example) treatment technologies for the 1100-EM-1 operable unit. The matrix includes contaminant setting, location of treatment application, associated pretreatment and posttreatment, and the form of the contaminant (liquid or solid). This matrix is shown in Tables 7-4 through 7-15.

7.2.3.5 Linking Treatment Technologies. Individual treatment technologies must usually be linked into remedial alternatives as necessary to provide the required level of protection of human health and the environment and to restore the remediated site. Site restoration may include emplacement of topsoil cover and revegetation. These final steps can be considered technologies that must be linked to other treatment technologies to complete an overall, effective remedial strategy.

Linking of specific unit technologies for the treatment of hazardous wastes will require consideration of the order in which they may be employed. Until the 1100-EM-1 operable unit is characterized and the presence of specific wastes is confirmed, attempting to establish a list of applicable technologies and an implementation sequence is inappropriate. However, certain processes must precede or follow other processes. For example, in the event that organic chemicals are present, they need to be removed prior to any type of ion exchange. Organics destroy the exchange capacity of ion exchange resin. Similarly, cation exchange must precede anion exchange. If the reverse sequence were applied, the alkaline waste effluent from the anion exchanger would cause precipitation of heavy metals on the cation exchange resin. This result would destroy the exchange capacity of the cation resin, rendering the exchanger useless. To maximize efficiency, some unit technologies must follow others. For this reason, filtration typically follows precipitation. Some waste species, such as heavy metals in solution, generally require a processing sequence of three or more unit processes. Typically, the first unit processes concentrate the contaminants so that subsequent processes can more efficiently and economically recover or solidify the wastes for final disposal.

Applicable remedial technologies will be linked together in sequence as appropriate to create remedial alternatives for each medium at each site. The linking of unit technologies for the purpose of developing each specific remedial alternative will depend on the analysis of data during the Phase I RI. The unit technologies to be considered will depend not only on the presence of specific hazardous waste species but also on their concentrations and the required levels of remediation. Other factors to be considered include the spatial distribution of contaminants and their mobilities. Until such information is available for the 1100-EM-1 operable unit, linking technologies into remedial alternatives is premature.

Table 7-4. Source Treatment of Heavy Metals.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
Mercury Chromium Arsenic Lead	1. In situ vitrification 2. In situ stabilization 3. Ion-exchange barrier 4. Barrier cutoff (caps and walls)	1. Flushing/pumping 2. Excavation	A. Solid state 1. Encapsulation with a. Organics, (bitumen, plastics, epoxies, etc.) b. Cements 2. Vitrification B. Aqueous/solvent state 1. Hydroxide precipitation ^a 2. Sulfide precipitation 3. Carbonate precipitation 4. Aluminum chloride precipitation 5. Ion exchange 6. Reverse osmosis 7. Evaporation/distillation (ponds) 8. Electrodialysis 9. Supported liquid membrane separation 10. Ultrafiltration	A. Solid state 1. Redeposit of solidified source material 2. Soil cover/revegetation B. Aqueous stream effluents 1. Water disposal a. Spray irrigation b. Direct discharge 2. Sludge/resin a. Solidification (organics, cement, and glass) b. Filtration followed by above processes C. Shipping/disposal preparation 1. Containerization a. Source material b. Extracted/concentrated contaminants

^aChrome may require pretreatment to reduce Cr^{+6} to Cr^{+3} prior to hydroxide precipitation.

Table 7-5. Soil Treatment of Heavy Metals.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
Mercury Chromium Arsenic Lead	1. In situ vitrification 2. In situ stabilization 3. Ion-exchange barrier 4. Barrier cutoff (caps and walls)	1. Flushing/pumping 2. Excavation	A. Solid state 1. Encapsulation with a. Organics, (bitumen, plastics, epoxies, etc.) b. Cements 2. Vitrification B. Aqueous/solvent state 1. Hydroxide precipitation ^a 2. Sulfide precipitation 3. Carbonate precipitation 4. Aluminum chloride precipitation 5. Ion exchange 6. Reverse osmosis 7. Evaporation/distillation (ponds) 8. Electrodialysis 9. Supported liquid membrane separation 10. Ultrafiltration	A. Solid state 1. Redeposit of solidified source material 2. Soil cover/revegetation B. Aqueous stream effluents 1. Water disposal a. Spray irrigation b. Direct discharge 2. Sludge/resin a. Solidification (organics, cement, and glass) b. Filtration followed by above processes C. Shipping/disposal preparation 1. Containerization a. Source material b. Extracted/concentrated contaminants

^aChrome may require pretreatment with SO₂ to reduce Cr + 6 to Cr + 3 prior to hydroxide precipitation.

Table 7-6. Groundwater Treatment of Heavy Metals.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
Mercury Chromium Arsenic Lead	<ol style="list-style-type: none"> 1. Ion-exchange barrier 2. Barrier cutoff 3. Chemical precipitation <ol style="list-style-type: none"> a. pH b. Redox 	<ol style="list-style-type: none"> 1. Pump for treatment 2. Pump for hydraulic cutoff 	<ol style="list-style-type: none"> A. Aqueous/solvent state <ol style="list-style-type: none"> 1. Hydroxide precipitation^a 2. Sulfide precipitation 3. Carbonate precipitation 4. Aluminum chloride precipitation 5. Ion exchange 6. Reverse osmosis 7. Evaporation/distillation (ponds) 8. Electrodialysis 9. Supported liquid membrane separation 10. Ultrafiltration 11. Solvent extraction 	<ol style="list-style-type: none"> A. Aqueous stream effluents <ol style="list-style-type: none"> 1. Water disposal <ol style="list-style-type: none"> a. Spray irrigation b. Direct discharge 2. Sludge/resin <ol style="list-style-type: none"> a. Solidification (organics, cement, and glass) b. Filtration followed by above processes B. Shipping/disposal preparation <ol style="list-style-type: none"> 1. Containerization of solidified waste, sludges, and resins

^aChrome requires pretreatment to reduce Cr^{+6} to Cr^{+3} prior to hydroxide precipitation.

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Table 7-7. Source Treatment of Toxic Anions.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
Nitrates Sulfates	<ol style="list-style-type: none"> 1. In situ vitrification 2. In situ biotreatment ^b 3. Barrier cutoff 4. Ion-exchange barrier 5. In situ solidification 	<ol style="list-style-type: none"> 1. Flushing/pumping 2. Excavation 	<ol style="list-style-type: none"> A. Solid state^a B. Aqueous/solvent state <ol style="list-style-type: none"> 1. Anaerobic biological treatment^b 2. Anion exchange 3. Reverse osmosis 4. Electrodialysis 5. Evaporation/distillation 6. Supported liquid membrane separation 7. Ultrafiltration 	<ol style="list-style-type: none"> A. Same treatments as heavy metal residuals if destruction is not employed B. Degassing/stripping of NO_x and SO_x if destruction is employed B. Shipping/disposal preparation <ol style="list-style-type: none"> 1. Containerization <ol style="list-style-type: none"> a. Source material b. Extracted/concentrated contaminants

NOTE: Other contaminants may act as carbon source.

^aSee notes for heavy metals.

^bRequires addition of nutrients, carbon source, and proper microbes.

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Table 7-8. Soil Treatment of Toxic Anions.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
Nitrates Sulfates	1. In situ vitrification 2. In situ biotreatment ^b 3. Barrier cutoff 4. Ion-exchange barrier 5. In situ solidification	1. Flushing/pumping 2. Excavation	A. Solid state ^a B. Aqueous/solvent state <ol style="list-style-type: none"> 1. Anaerobic biological treatment^b 2. Anion exchange 3. Reverse osmosis 4. Electrodialysis 5. Evaporation/distillation 6. Supported liquid membrane separation 7. Ultrafiltration 	A. Same treatments as heavy metal residuals if destruction is not employed B. Degassing/stripping of NO _x and SO _x if destruction is employed B. Shipping/disposal preparation <ol style="list-style-type: none"> 1. Containerization <ol style="list-style-type: none"> a. Source material b. Extracted/concentrated contaminants

NOTE: Other contaminants may act as carbon source.

^aSee notes for heavy metals.

^bRequires addition of nutrients, carbon source, and proper microbes.

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Table 7-9. Groundwater Treatment of Toxic Anions.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
Nitrates Sulfates	1. In situ biotreatment ^b 2. Grout barrier cutoff 3. Ion-exchange barrier	1. Pump and treat for flushing 2. Pump and treat for hydraulic cutoff	A. Aqueous/solvent state 1. Anaerobic biological treatment ^b 2. Anion exchange 3. Reverse osmosis 4. Electrodialysis 5. Evaporation/distillation 6. Supported liquid membrane separation 7. Ultrafiltration	A. Same treatments as heavy metal residuals if destruction is not employed. B. Degassing/stripping of NO_x and SO_x from aqueous stream if destruction is employed C. Shipping/disposal preparation 1. Containerization of solidified source material

NOTE: Other contaminants may act as carbon source.

^aSee notes for heavy metals.

^bRequires addition of nutrients, carbon source and proper microbes.

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Table 7-10. Source Treatment of Aromatics.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
(Nonchlorinated aromatics)	1. In situ vitrification	1. Flushing/pumping	A. Solid state	A. Treated source/soil
Benzene	2. In situ biotreatment ^a	2. Steam extraction	1. Encapsulation with	1. Redeposit of solidified or treated soil/revegetation
Toluene			a. Organic binders	2. Soil cover/vegetation
Xylene	3. Grout barrier cutoff	3. Excavation	b. Cements	B. Aqueous stream effluents
Di-n-octyl phthalate	4. Activated carbon barrier cutoff		2. Incineration ^b	1. Wastewater disposal (treated)
Bis (2 ethylhexyl phthalate	5. In situ solidification		3. Glass melter vitrification	a. Spray irrigation
(Chlorinated aromatics)	6. In situ heating		4. Plasma arc furnaces ^b	b. Direct discharge
Polychlorinated biphenyl			B. Aqueous/solvent phase	2. Sludge/carbon
			1. Catalytic reduction/oxidation	a. Solidification (with cement, organics, or glass)
			2. Wet air oxidation	b. Filtration followed by solidification
			3. Aerobic biological treatment	C. Shipping/disposal preparation
			4. Ultraviolet irradiation	1. Containerization
			5. Ozonation	a. Solidified source material
			6. Chemical oxidation	b. Extracted/concentrated contaminants
			7. Activated carbon	
			8. Incineration ^b	

^aMay require addition of microbes, nutrients, and oxygen as H₂O₂, etc.^bAny thermal process with temperatures in excess of 2400 °F at standard pressure.

Table 7-11. Soil Treatment of Aromatics.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
(Non-chlorinated aromatics) Benzene Toluene Xylene di-n-octyl phthalate Bis (2 ethylhexyl phthalate) (Chlorinated aromatics) Polychlorinated biphenyl	1. In situ vitrification 2. In situ biotreatment ^a 3. Grout barrier cutoff 4. Activated carbon barrier cutoff 5. In situ solidification 6. In situ heating	1. Flushing/pumping 2. Steam extraction 3. Excavation	A. Solid state 1. Encapsulation with a. Organic binders b. Cements 2. Incineration ^b 3. Glass melter vitrification 4. Plasma arc furnaces ^b B. Aqueous/solvent phase 1. Catalytic reduction/oxidation 2. Wet air oxidation 3. Aerobic biological treatment 4. Ultraviolet irradiation 5. Ozonation 6. Chemical oxidation 7. Activated carbon 8. Incineration ^b	A. Treated source/soil 1. Redeposit of solidified or treated soil/revegetation 2. Soil cover/revegetation B. Aqueous stream effluents 1. Wastewater disposal (treated) a. Spray irrigation b. Direct discharge 2. Sludge/carbon a. Solidification (with cement, organics, or glass) b. Filtration followed by solidification C. Shipping/disposal preparation 1. Containerization a. Solidified source material b. Extracted/concentrated contaminants

^aMay require addition of microbes, nutrients, and oxygen as H₂O₂, etc.^bAny thermal process with temperatures in excess of 2400 °F at standard pressure.

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Table 7-12. Groundwater Treatment of Selected Organics.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
Benzene Toluene Xylene Di-n-octyl phthalate Bis (2 ethylhexyl) phthalate Polychlorinated biphenol	1. In situ biotreatment ^a 2. Grout barrier cutoff 3. Activated carbon barrier cutoff 4. In situ solidification 5. In situ heating	1. Pump and flush 2. Pump and treat for hydraulic cutoff	A. Aqueous phase/solvent phase 1. Catalytic reduction/oxidation 2. Wet air oxidation 3. Aerobic biological treatment 4. Ultraviolet irradiation 5. Ozonation 6. Chemical oxidation 7. Activated carbon 8. Incineration ^b	A. Aqueous stream effluents 1. Wastewater disposal (treated) a. Spray irrigation b. Direct discharge 2. Sludge/carbon a. Solidification in cement, organics, and glass b. Filtration followed by solidification B. Shipping/disposal preparation 1. Containerization of solidified waste

^aMay require addition of microbes, nutrients, and oxygen as H₂O₂, etc.

^bAny thermal process with temperatures in excess of 2400 °F at standard pressure.

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Table 7-13. Source Treatment of Chlorinated Aliphatics.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
(Chlorinated aliphatics) Methylene chloride Carbon tetrachloride Perchloroethylene Trichloroethylene 1,1,1 trichloroethane	1. In situ vitrification 2. In situ solidification 3. Activated carbon barrier 4. Air-stripping soil-gas extraction 5. Steam stripping 6. Barrier cutoff (caps and walls) 7. In situ heating	1. Flushing/pumping 2. Excavation	A. Solid state 1. Encapsulation a. Organic binders b. Cements 2. Thermal destruction ^a a. Vitrification b. Incineration c. Plasma arc furnaces B. Aqueous phase/solvent phase 1. Catalytic reduction/oxidation 2. Wet air oxidation 3. Biological treatment 4. Ultraviolet irradiation 5. Ozonation 6. Chemical oxidation 7. Activated carbon 8. Air stripping 9. Steam stripping 10. Incineration ^a	A. Treated source/soil 1. Redeposit of solidified or treated soil/revegetation 2. Soil cover/revegetation B. Aqueous phase effluents 1. Wastewater disposal (treated) a. Spray irrigation b. Direct discharge 2. Sludge/carbon a. Solidification (cement, organics, and glass) b. Filtration followed by solidification C. Vapor phase effluents 1. Thermal treatment ^a 2. Activated carbon scrubbing followed by above

^aRequires temperature at or above 2400 °F to break carbon chloride bond at ambient pressure.

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Table 7-14. Soil Treatment of Chlorinated Aliphatics.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
(Chlorinated aliphatics) Methylene chloride Carbon tetrachloride Perchloroethylene Trichloroethylene 1,1,1 trichloroethane	1. In situ vitrification 2. In situ solidification 3. Activated carbon barrier 4. Air-stripping soil-gas extraction 5. Steam stripping 6. Barrier cutoff (caps and walls) 7. In situ heating	1. Flushing/pumping 2. Excavation	A. Solid state 1. Encapsulation a. Organic binders b. Cements 2. Thermal destruction ^a a. Vitrification b. Incineration c. Plasma arc furnaces B. Aqueous phase/solvent phase 1. Catalytic reduction/oxidation 2. Wet air oxidation 3. Biological treatment 4. Ultraviolet irradiation 5. Ozonation 6. Chemical oxidation 7. Activated carbon 8. Air stripping 9. Steam stripping 10. Incineration ^a	A. Treated source/soil 1. Redeposit of solidified or treated soil/revegetation 2. Soil cover/revegetation B. Aqueous phase effluents 1. Wastewater disposal (treated) a. Spray irrigation b. Direct discharge 2. Sludge/carbon a. Solidification (cement, organics, and glass) b. Filtration followed by solidification C. Vapor phase effluents 1. Thermal treatment ^a 2. Activated carbon scrubbing followed by above

^aRequires temperature at or above 2400 °F to break carbon chloride bond at ambient pressure.

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Table 7-15. Groundwater Treatment.

Contaminants	In situ	Onsite/offsite		
		Pretreatment	Primary treatment	Secondary treatment
(Chlorinated aliphatics) Methylene chloride Carbon tetrachloride Perchloroethylene Trichloroethylene 1,1,1 trichloroethane	1. Activated carbon barrier 2. Air-stripping soil-gas extraction 3. Steam stripping 4. Barrier cutoff (caps and walls) 5. In situ heating	1. Pump and treat for flushing 2. Pump and treat for hydraulic cutoff	A. Aqueous phase/solvent phase 1. Catalytic reduction/oxidation 2. Wet air oxidation 3. Biological treatment 4. Ultraviolet irradiation 5. Ozonation 6. Chemical oxidation 7. Activated carbon 8. Air stripping 9. Steam stripping	A. Aqueous phase effluents 1. Wastewater disposal (treated) a. Spray irrigation b. Direct discharge 2. Sludge/carbon a. Solidification (cement, organics, and glass) b. Filtration followed by solidification B. Vapor phase effluents 1. Thermal treatment ^a 2. Activated carbon scrubbing followed by above C. Shipping/disposal preparation 1. Containerization a. Solidified waste b. Spent carbon c. Extracted contaminants

^aRequires temperature at or above 2400 °F to break carbon chloride bond at ambient pressure.

7.3 INITIAL SCREENING (PHASE II, FEASIBILITY STUDY)

This section of the technology plan provides a description of required FS Phase II activities. Following the development of remedial alternatives is an initial screening of the alternatives. The purpose of this activity is to narrow the list of remedial alternatives to those that are feasible. Analyses required to determine which alternatives are most viable will subsequently be identified, such as performance of treatability studies. The results from treatability studies are used to develop conceptual engineering designs, size unit technologies, and assess performance of the treated waste.

The methodology for the initial screening of remedial alternatives and the subsequent treatability testing are described in this section of the work plan. Several of the most likely unit technologies for the 1100-EM-1 operable unit are identified and the associated treatability testing activities are described.

7.3.1 Initial Screening Methodology

The SARA guidance document (EPA 1988a) states that, "The objective of alternative screening is to narrow the list of potential alternatives (based on their effectiveness, implementability, and cost) that will be evaluated in detail. This screening aids in streamlining the feasibility study process while ensuring that the most promising alternatives are being considered."

Preliminary alternative technologies have been assembled from well-developed technologies based on estimates of contaminants likely to be present in the 1100 Area (see Section 7.3.2.3 and Appendix F). The alternatives selected for screening probably will change as more information is available for each site. The remedial alternatives will be considered on a medium-specific and a zone- or unit-specific basis after data on contaminant sources and distribution are available. Per requirements in EPA (1988a), the following information will be developed for each remedial alternative.

- Size and configuration of onsite extraction and treatment systems or containment structures--For media contaminated with several hazardous substances, it may be necessary to first determine which contaminant(s) impose the greatest treatment requirements; then size or configure accordingly. Similarly, for groundwater extraction technologies at sites with multiple groundwater contaminants, it may be necessary to evaluate which compounds impose the greatest limits on extraction technologies because of their chemical/physical characteristics, concentration, or distribution in groundwater.
- Time frame in which treatment, containment, or removal goals can be achieved--The remediation time frame is often interdependent on the size of a treatment system or configuration of a groundwater extraction system. The time frame may be based on specific remediation goals (e.g., attaining groundwater remediation goals in 10 yr), in which case the technology is sized and configured to achieve this; the time frame may also be influenced by

technological limitations (such as maximum size consideration, performance capabilities, and/or availability of adequate treatment systems or disposal capacity).

- Rates or flows of treatment--These will also influence the sizing of technologies and time frame within which remediation can be achieved.
- Spatial requirements for constructing treatment or containment technologies or for staging construction materials or excavated soil or waste.
- Distances for disposal technologies--These include approximate transport distances to acceptable offsite treatment and disposal facilities and distances for water pipelines for discharge to a receiving stream or a publicly owned treatment works.
- Required permits and imposed limitations--These include national pollutant discharge elimination system, pretreatment, and emission control requirements; coordination with local agencies and the public; and other legal considerations. These may also encompass some action-specific as well as location- and chemical-specific ARARs.

In addition, each remedial alternative must be as well defined as the available data will allow in terms of effectiveness, implementability, and cost. Each of these factors is discussed in the ensuing sections.

7.3.1.1 Effectiveness. There are a number of considerations when evaluating the effectiveness of a remedial alternative. Primary among these is the ability to reduce the risk posed by the waste site to an acceptable level. Before evaluating the effectiveness of a remedial alternative, some knowledge of the spatial distribution of the waste and transport descriptions (models) for the contaminants is required. (See Section 7.2.1.) A remedial alternative that emphasizes treatment of groundwater is ineffective if the source continues to release contaminants into the groundwater. Various containment alternatives can be postulated on the basis of blocking the various transport pathways. Until these pathways and contaminant release rates through these pathways are understood, remedial alternatives cannot be evaluated properly.

Certain remedial alternatives may significantly reduce the volume of the hazardous waste, but may not alter the specific toxic properties of the waste. Such alternatives could actually increase the health risk due to the potential of exposure to more concentrated hazardous chemicals. With other remedial alternatives, the volume of contaminated material may remain unchanged while the toxic properties are reduced. In this case, risk would likely be reduced. Thus, effectiveness must be based on comparative evaluation of the reduction of total lifetime health risk to the target population. Therefore, criteria for the evaluation of effectiveness of each remedial alternative should be protective of human health and the environment based on reduction in toxicity and reduction in mobility.

7.3.1.2 Implementability. Implementability encompasses institutional feasibility and operational feasibility. Institutional feasibility pertains to the acceptability of a remedial alternative by regulatory agencies, the general public, Westinghouse Hanford, DOE, and possibly others not presently identified. For example, a specific remedial alternative may require use of a RCRA-permitted landfill for disposal of some or all of the waste and waste-contaminated soil. Unavailability of a landfill or inability to obtain a permit may preclude certain alternatives. Such alternatives are not "implementable." In the case of the 1100-EM-1 operable unit, this would not appear to be a constraint. Pending the results of the RI Phase I analysis of site contamination, the RCRA-permitted landfill at Arlington, Oregon, may be available for the disposal of nonradioactive contaminated wastes and soil. Other institutional considerations will depend on review of the various products of the 1100-EM-1 RI/FS process by both the regulatory agencies and the general public. Providing the necessary guidance on institutional issues as the remedial alternatives are developed and screened is the responsibility of EPA Region X. To the extent that the Federal Facilities Agreement and the action plan address the institutional considerations, these documents will provide guidance as to the implementability of the remedial alternatives for the 1100-EM-1 operable unit.

Operational feasibility involves those factors that will impact the construction, operation, and maintenance of the alternative at the 1100-EM-1 operable unit. While a particular remedial alternative may be capable of eliminating any risks to the environment or public health, it may increase risk to the public health and environment during the construction phase. Remedial alternatives that include excavation of the source and/or the contaminated soil must take this possible risk elevation into consideration. The potential for release to the atmosphere during the excavation or during stockpiling of the contaminated materials may be cause for eliminating an otherwise acceptable remedial alternative. This will depend on the nature of the contamination, prevailing ambient conditions (wind, temperature, etc.), and location of the target population. Areas of the 1100-EM-1 operable unit are located such that the foregoing factors will be a major consideration.

Another operational consideration that can impact implementability is the availability of qualified personnel and suitable equipment. The ability to maintain institutional control over the 1100-EM-1 operable unit for extended periods into the future is another factor to be considered in evaluating implementability. Planned release of institutional control of the site will preclude consideration of remedial alternatives that include certain containerization or isolation technologies. The expected loss of site control will result in greater emphasis on technologies that destroy or reduce waste toxicity.

7.3.1.3 Costs. During the screening process, detailed cost estimates are not required. The purpose of performing cost analysis at this stage is to make an "order of magnitude" comparison of costs among remedial alternatives. To the extent that information is available, both capital as well as operating and maintenance costs should be considered. These costs can be developed from prior experience reported in the literature and generic cost factors based on scale. The EPA has published a number of documents indicating costs based on physical scale for the treatment of wastes using

specific treatment processes. Other sources of cost information include vendor information and, finally, best technical judgement should be practiced when no other source of information is available.

For comparative purposes, all costs should be discounted (or inflated) to a common year. The preferable base is the present year. This results in a calculation of present worth and should include lifetime costs. If costs for remedial alternatives are within an order of magnitude, costs should not be a criterion for elimination of a more expensive remedial alternative unless a full range of similarly costly options can be identified for further consideration.

7.3.2 Treatability Study Objectives

Once the initial screening of remedial action alternatives has been completed, each alternative must be further evaluated to determine its preference relative to other alternatives. As these evaluations are conducted, data needs are identified that often must be satisfied by conducting treatability studies. This section describes the objective, general approach, and approach for conducting specific treatability studies.

7.3.2.1 Objective of Treatability Studies. The following are primary objectives for conducting treatability studies.

- Obtain sufficient data for each alternative or combination of alternatives so that a detailed analysis of each can be fully developed to support the process of evaluating and selecting a remedial action for implementation.
- Provide data to support detailed design of a selected alternative.
- Provide data to reduce cost and risk of a selected alternative.

7.3.2.2 General Approach for Conducting Treatability Studies. The decision process for treatability investigations consists of the following steps.

- Determine data needs.
- Review existing data on the site and available technology literature to determine if existing data are sufficient to evaluate alternatives and establish DQOs.
- Perform treatability tests as appropriate to determine performance, operating parameters, and relative costs of potential remedial technologies.
- Evaluate the data to ensure that DQOs are met.

The purpose of reviewing existing literature and site data is to determine the adequacy of the available data to support the performance/risk assessment of alternatives and the design of selected alternatives. The following are objectives of the literature search.

- Determine whether or not the performance of each alternative has been sufficiently documented on similar wastes in process-scale and full-scale applications.
- Gather information on relative costs, applicability, removal efficiencies, operations and maintenance requirements, and the implementability of the alternative to identify specific data needs that may become part of the treatability test objectives.
- Determine the specific test procedures that will be employed to develop the process design data.

Information obtained from a literature search includes controlling parameters (both independent and dependent), other factors that affect performance, and input requirements. Independent controlling parameters include those parameters that control the process and establish nominal performance specifications. Flow rate, process temperature or pressure, or nutrient requirements are examples of independent controlling parameters. Alternatively, dependent controlling parameters include treatment efficiency and secondary products that are functions of the independent parameters.

Information on other factors affecting performance is required to adequately assess and design a process and can often be obtained from a literature search. Examples of these factors include adverse soil characteristics that could impact process performance, toxic materials that could inhibit microbial growth rates in a biological treatment, or presence of chemicals that could poison catalysts. In addition, the sequencing of individual treatment processes must be considered. Information on the effect of upstream processing steps on the performance of downstream processes is also important.

Finally, the literature can often provide information on input requirements such as energy and materials needed to operate a process. This information is used to determine annual operating costs during the cost analysis that is conducted for each alternative in Phase III of the FS to support the selection process.

Based on the results of the literature search, a determination of the data needs is made, DQOs are established, and the test procedure is developed for the treatability tests. Typically, treatability tests will be required unless either the technology is fully developed and well proven on hazardous wastes similar to those requiring remediation or relatively low removal efficiencies are required and available data are adequate for designing such a process. Generally, technologies have not been sufficiently demonstrated or the characterization of the waste alone is insufficient to reliably predict full-scale treatment performance and cost estimates. Consequently, treatability tests will be conducted to determine controlling parameters, effects of other factors on performance, or input requirements.

Upon completion of the literature search, the next step is to determine the type of testing (i.e., bench- or pilot-scale) to be performed. This decision must take into account the type of data desired and the ability to extrapolate it to full scale. Therefore, the reliability of process models, level of development of the technology, site characteristics that could

affect performance, performance goals, and cost are all factors that need to be considered in this decision. For many well-developed technologies, the reliability of the models is either straightforward or well understood. For the technologies, determining a few parameters on the bench scale will be sufficient. For new or innovative technologies (innovative technologies are defined as existing technologies that have not been sufficiently demonstrated on hazardous waste), commercial- or pilot-scale data may be too limited or nonexistent. Under these conditions, testing will be necessary to ensure reliable scale-up data, to adequately determine the effects of adverse site characteristics, and to verify that performance goals can be met.

The costs for conducting these tests are related to number, type, and range of variables to be evaluated and to the scale. Bench-scale tests are typically inexpensive and are well suited to evaluating a large number of parameters and a wide range of parameter values. Pilot-scale tests are more expensive but reduce the uncertainty in scale-up. Therefore, in some cases, pilot tests will need to follow bench-scale testing, particularly in cases where the scale of the process affects performance. Typical parameters that are sensitive to scale are mixing, wall effects, accurate settling data, and generation of sufficient residues (i.e., sludge, offgas, etc.) for subsequent testing.

The cost tradeoff between the potential for improved performance or savings in time or money during implementation of the technology and the cost for testing during the RI/FS process has been considered in this work plan. In the special case of Hanford Site wastes, this consideration extends to the possibility that the technology would be a potential candidate for more than one hazardous waste site.

The final step in performing treatability testing is developing and conducting the treatability tests. To develop the tests, preplanning activities need to be completed. These activities include detailed planning of the test procedures, waste sampling, and waste characterization.

7.3.2.3 Specific Approach to Conducting Treatability Studies. In preparation of this work plan, a limited literature review was conducted for the following 13 technologies that may apply to the 1100-EM-1 operable unit:

- Activated carbon
- Catalytic destruction
- Ceramic melter
- Encapsulation
- Chemical oxidation
- In situ vitrification
- Filtration
- Ion exchange

- Trickling filters
- Wet air oxidation
- Rotating biodiscs
- Incineration
- Airstripping.

The technologies listed above are discussed in detail in Appendix F. The bases for selecting these technologies were that they had established procedures or established applicability for the types of waste problems characteristic of the soils and groundwater in the 1100 Area. No new or innovative technologies were included. The information presented in Appendix F for each technology includes a process description, design models, design parameters, other factors affecting performance, a brief description of the type of treatability tests to be conducted, and references used to develop this information. This information is intended to provide the project manager with adequate information for budgeting and scheduling purposes as well as serving as a basis for detailed testing plans.

7.4 FEASIBILITY STUDY PHASE III

The third phase of the FS entails a detailed analysis of the alternatives to provide the decision-makers with sufficient information to select a remedy for the problems posed by the sites of the 1100-EM-1 operable unit. The screened alternatives from the second phase of the FS and the results of treatability studies serve as the primary inputs to this phase of the FS. The alternatives may need revision because of the results of the treatability studies or additional information from the RI. Each alternative will then be evaluated and compared to the others with respect to criteria established by the DOE, EPA, and Ecology.

The EPA (1988a) establishes nine evaluation criteria to address CERCLA requirements and technical policy considerations that have proven to be important in selecting among remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analyses during the FS and for selecting the remedial action (EPA 1988a). The nine criteria are as follows:

- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost
- Compliance with ARARs

- Overall protection of human health and the environment
- State acceptance
- Community acceptance.

Implementation of these criteria is discussed extensively in EPA (1988a).

The results of the evaluation and comparative analysis will be presented in the FS and be used as the basis for selecting the alternative to be implemented. This report must provide sufficient information to support the evaluation of each alternative with respect to the selection criteria. The work required to complete the Phase III FS is described in detail in Appendix G.

8.0 DATA MANAGEMENT PLAN

An extensive amount of data will be generated over the next several years in connection with the RI/FS process that will be conducted to evaluate and remediate hazardous waste sites at the Hanford Site. The quality of the data must be beyond reproach because they will be used to evaluate the need, select the method(s), and support the full remediation of the waste sites as agreed upon by the DOE, EPA, Ecology, and interested parties. Thus, a comprehensive plan for the management of this extensive amount of data is absolutely essential.

8.1 INTRODUCTION AND OBJECTIVES

An all-inclusive data management system (DMS) is not presently available for supporting the RI/FS work planned at the Hanford Site over the next several years.

This section describes a two-component DMS for accessing and tracking the receipt, storage, and control of validated data, records, documents, correspondence, and other associated information. These components include a computer-based component and an administrative component to handle, store, and protect physical records and samples.

This section outlines the following:

- Types of data and information that are expected to be collected
- Currently available computer-based and administrative components
- Plans for developing any needed interim administrative components
- Plans for developing a comprehensive computer-based component that integrates selected existing and anticipated computer data bases
- Plans for establishing an information repository for maintaining the official paper-copy (hard-copy) records and physical samples associated with each operable unit.

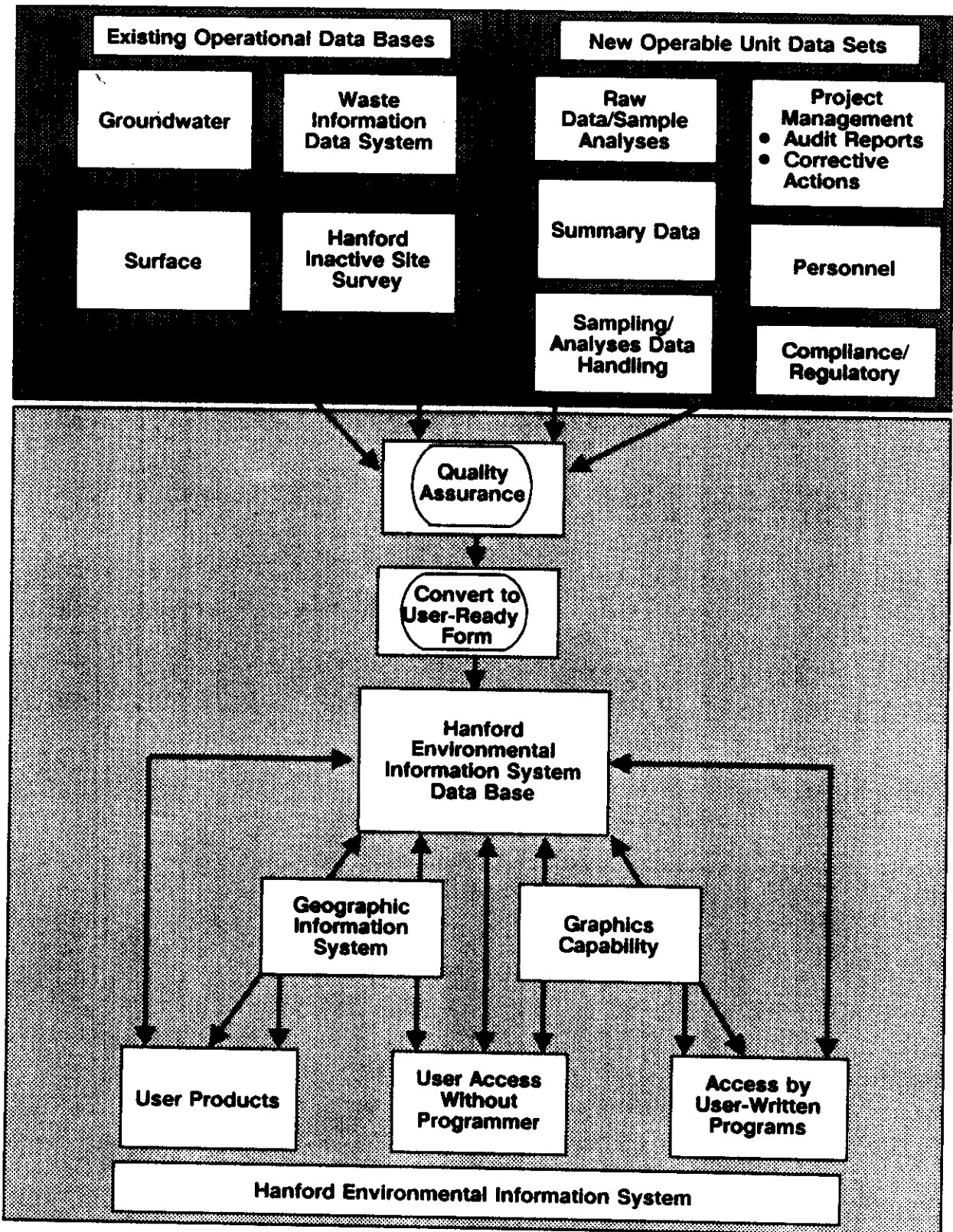
Procedures for the system will be developed for directing project-authorized personnel as to the manner in which data are received, stored, tracked, amended, and disseminated so that a record of control is always maintained. These procedures will be developed to ensure that the integrity of the data is maintained. The procedures will be provided in a detailed data system procedure manual that describes how data can be entered, accessed, processed, and amended so that a record of use and changes or modifications to the data is maintained. Accessibility of the data base by all interested parties will allow access as described in the agreement being developed by the DOE, EPA, and Ecology.

The data system procedures manual will include the procedures necessary for handling and tracking the information that must be maintained in the official (hard-copy) administrative record for each operable unit as well as physical paper-copy records and archived physical samples associated with each unit. It will also include procedures for operation and control of the computer-based component of the system. Existing procedures will be used or modified, or new procedures will be developed, to address records management for the following general subject areas:

- Congressional inquiries and hearings
- Discovery
- Remedial planning, investigation, and feasibility study
- Remedial design and implementation
- EPA and State agency coordination
- Community relations
- Imagery (photographs, maps, illustrations, etc.)
- Enforcement activities
- Contracts
- Financial records.

An environmental data management plan is being prepared for submittal to DOE-RL by March 31, 1989. The plan will address development of the data management system discussed here and will include as a task the development of the data system procedure manual mentioned above. The plan will detail requirements, procedures, and responsibilities for managing environmental data.

The computer-based component is the Hanford Environmental Information System (HEIS), currently being developed by PNL. The HEIS will be used to manage the extensive amount of data that will be collected and generated during the RI/FS and site-remediation processes. The HEIS is a computer-based information system that is designed to receive, store, and provide for access to quality-assured data concerning Hanford Site environmental and regulatory issues. As shown in Figure 8-1, the HEIS is an integrated data base designed to integrate existing operational data bases and provide facilities for data being gathered as part of the CERCLA process. This allows for accessing and evaluating the data that is collected and generated by the individual Hanford Site environmental data base programs [e.g., Hanford groundwater data base, surface monitoring program data and management system (PDMS), waste information data system (WIDS), Hanford inactive site survey (HISS)], while maintaining the integrity of the individual data bases.



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Figure 8-1. Framework of the Hanford Environmental Information System.

The HEIS will provide the following:

- User support capabilities
- A geographic information system
- Integrated graphics support
- Comprehensive user access capabilities
- Access by personal computers via existing networks
- Security of the data bases.

The computer-based component will serve to list and locate paper records and physical samples. The HEIS will maintain much of the various types of raw site (operable unit) data, verified program and summary data, and results of approved analytical computer programs. The results of such analyses will be stored separately from the original data files.

The ability to enter data into raw data files will be restricted to maintain control of validated data. Any changes required to validate data will be procedurally controlled to restrict qualified data from being inadvertently or intentionally altered. All changes will be documented and maintained in the system.

The official paper-copy records (administrative record as well as other official paper-copy records) and archived physical samples will be maintained in designated areas that will be specified in the data system procedures manual. The designated areas will be designed such that they will meet all applicable protection and security requirements. Backup record copies will be maintained in accordance with applicable procedures (now under development).

8.2 TYPES OF DATA TO BE COLLECTED AND ANALYZED

Records and types of data to be tracked during the RI/FS process at the Hanford Site are shown in Table 8-1. The "raw data" represents the actual field and laboratory measurements or observations that will be made during the RI/FS processes. The "summary data" represents the first-order analyses of the "raw data." "Program tracking" includes information that is programmatic or administrative in nature. It represents the data that are required for the conduct of a project; however, it does not include the field or laboratory data.

Validated data gathered during RI/FS investigations will be kept separate from other Hanford Site project data by placement in separate files within the data management system. However, many of the ongoing Hanford Site projects will provide data that will undoubtedly be very useful for the Hanford Site RI/FS investigations. Data will be stored such that they may be accessed for analyses, the results of which will be stored separately.

Table 8-1. Types of Remedial Investigation/Feasibility Study Information and Data to be Collected.

Characterization	
Raw data/sample analyses	Groundwater samples Sediment samples Surface water samples Atmospheric samples Personnel exposure monitoring records Geophysical information Biota samples Site descriptive information (topography, geological and ecological features) Pilot/bench test data Engineering design data
Summary data	Analytical results of environmental media by time, location, depth, contaminant, etc. Health risk assessment results Engineering test results Graphic information system outputs
Sampling/analyses/data handling	Sampling schedule Sample collection procedures Field/laboratory notebooks Analyses scheduling Laboratory quality assurance/quality control Calibration tracking Instrument coordination Data entry procedures Data reduction, validation, storage and transfer procedures
Tracking	
Project management	Project schedule and milestones Project costs Equipment, personnel, and supplies scheduling Document tracking Subcontracts Project quality assurance/quality control procedures
Personnel	Personnel training and qualifications Occupational exposure records Personnel health and safety records
Compliance/regulatory	Applicable or relevant and appropriate requirements/screening levels Guidance document tracking Compliance issues Problem resolution

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A reference collection of applicable EPA, Ecology, DOE, and Hanford Site contractor documents, drawings, and correspondence will be maintained to support site characterization and remedial investigation activities. The ARARs drawn from Federal and State requirements and standards will be kept and updated in a timely manner. Compliance requirements will also be maintained and updated periodically.

8.3 DATA MANAGEMENT PLAN SCOPE RELATIVE TO OTHER REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN COMPONENTS

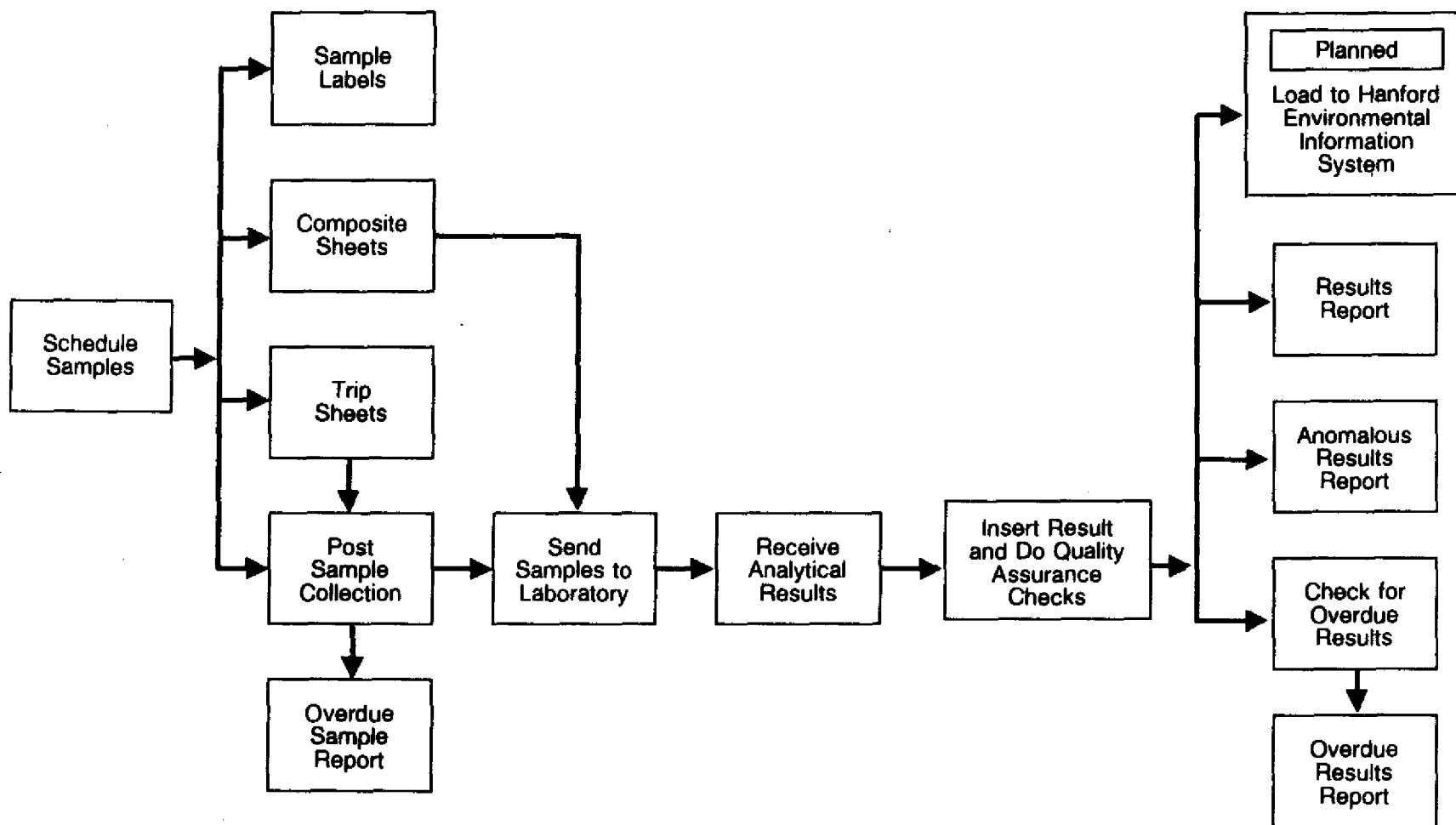
The DMS will receive and control validated data obtained through implementation of the SAP, HASP, and technology plan segments of this work plan. The QA plan includes provisions to ensure quality data and results of analyses. The SAP provides the detailed logistical methods to be employed in selecting the location, depth, frequency of collection, etc., of media to be sampled and methods to be employed to obtain samples of the selected media for cataloging, shipment, and analyses. The data that result from the analyses will be entered into the DMS for subsequent control and tracking. In a similar manner, data from field and bench tests of potential remedial techniques is entered into the DMS. Procedural control for such testing is found in the QA plan. Specific directions and logistical methods to be employed for field and bench testing are found in the technology plan. Site and personnel health data needed to ensure worker safety are specified in the HASP, which also specifies the manner in which these data are to be obtained. Personnel health records will be protected as required by the Privacy Act and secured in such a way that only authorized personnel will have access to these data.

8.4 PROCEDURAL CONTROL OF DATA MANAGEMENT SYSTEM

The DMS will be procedurally regulated by the data systems procedure manual to be developed. As specified in the environmental data management plan (to be developed by March 1989), an in-process document control procedure and 1100-EM-1 procedure will be utilized in the interim (see also Appendix C). A specific example relating to surface environmental monitoring is given in Figure 8-2.

8.5 IDENTIFICATION OF EXISTING DATA BASE SYSTEMS

Several data bases are currently in use at the Hanford Site. These data bases were developed for a variety of different purposes and uses. However, much of the information and data-handling capabilities associated with these data bases is directly useful to RI/FS evaluation of the various operable units located on the Hanford Site. A listing of the existing data bases that are available is provided in Table 8-2.



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Figure 8-2. Example Procedure for Collecting, Handling, and Analyzing Samples and for Entry of the Results.

Table 8-2. Existing Hanford Data Bases.

Data base name	Information type
Hanford Groundwater Data Base	Contains chemical and radionuclide analytical results for groundwater and sediment samples
Program Data and Management System	Contains chemical and radionuclide analytical results of air, surface water, soil, vegetation, wildlife, and foodstuffs samples
Waste Information Data System	Contains information on the physical and environmental characteristics of waste units at the Hanford Site (radioactive and hazardous chemicals)
Hanford Inactive Site Survey	Contains detailed preliminary assessment/site inspection information on individual waste sites at the Hanford Site
Hanford Environmental Compliance Report	Contains information on Hanford Site waste streams for tracking environmental compliance issues
Environmental Compliance Tracking System	Contains regulatory flowsheet information for tracking compliance with Federal, State, and local environmental regulations
Sample Preparation System	Generates labels, reports, etc. for sampling preparation and contains information on facilities, location, and time of sampling and chain-of-custody information
Basalt Waste Isolation Project Technical Data System	Contains information on hydrological conditions and some geological data for the Hanford Site. Also contains site characterization, hydrological data, hydrochemistry, stratigraphy, and constituent data
Warehouse Inventory Management System	Keeps track of all the hazardous material purchased at the Hanford Site
Flow Gemini--Environmental Information System	Will contain information associated with onsite monitoring for exposures to hazardous materials (e.g., monitoring well drilling for gaseous releases)
Flow Gemini--Occupational Health Information System (medical information tracking system)	Contains employee medical information
Material Safety Data Sheet System	Contains information on chemicals found at the Hanford Site. Currently this is a manual system operated by HEHF, but it is in the process of being computerized. This effort is being coordinated with the SARA Title III right-to-know program at the Hanford Site
Occupational Radiation Exposure	Contains personnel respiratory protection fitting, work restriction, and radiation exposure information
Quality Control Blind Standards Data Base	Contains the results on spiked samples, replicate samples, and interlaboratory comparisons
Training Records Information System	Contains records on individual employee training records
Commitment Control System	Tracks correspondence commitments. A network version is available

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Westinghouse Hanford maintains an Environmental Resource Center that contains copies of environmental and pertinent Federal and Washington State regulations, documents that have been prepared and submitted to Ecology and EPA pertaining to the regulations, and correspondence in support of environmental matters. The Environmental Resource Center contains RCRA permit applications and closure plans as well as RI/FS work plans for individual Hanford Site operable units. Other information such as environmental laws, DOE orders, corporate policies, and case histories will also be added. A computer-based indexing system is presently being developed and will allow rapid identification of appropriate documents, copies of which can be obtained from the Environmental Resource Center files. The Environmental Resource Center will contain copies of all correspondence with Ecology and EPA. This will include primary as well as secondary documents.

8.6 EVALUATION OF EXISTING DATA-BASE SYSTEMS

In general, the existing data bases in use on the Hanford Site were designed for specific purposes. They are not integrated to cover anticipated RI/FS needs. These existing data bases will provide supplementary, historical data to support the RI/FS process. The scope of each data base identified in Table 8-2 is discussed separately in the following paragraph.

The Hanford groundwater data base is used to generate the annual "Groundwater Monitoring at Hanford" report. It also contains the Hanford Site's RCRA compliance-monitoring program's groundwater monitoring data. In addition, it has been modified to handle vadose zone (sediment) sample data.

The PDMS is generally used by the Hanford Site to generate the annual "Surface Environmental Monitoring at Hanford" report. It is an overall data base for tracking routine and special air, surface-water, soil, vegetation, wildlife, and foodstuff samples from the Hanford Site.

The WIDS and the HISS data bases were set up specifically to handle hazardous waste site information. The WIDS contains data on the general physical and environmental characteristics associated with the waste units located on the Hanford Site. The HISS contains preliminary assessment/site inspection information on inactive sites at the Hanford Site including fairly detailed information on location, date for receiving waste, types and quantities of waste, cleanup actions, and other similar types of information. In addition, the HISS is supported by the PNL hazard ranking system and modified hazard ranking system evaluation data base, which contains the detailed hazard ranking system and modified hazard ranking system scoring information, with input parameter justifications, for individual waste sites at the Hanford Site. The WIDS system serves as the official Hanford Site waste units identification and tracking system.

The Hanford Environmental Compliance Report (HECR) and Environmental Compliance Tracking System (ECTS) are two systems currently used at the Hanford Site to track compliance. The HECR was developed to provide a uniform method for Hanford Site contractors to use in collecting and

maintaining regulatory compliance status information on Hanford Site facilities. Data input into HECR centers primarily around compliance with the various State and Federal legislation that may apply to a particular discharge point at the facility. The discharge point is the primary level for which compliance data are entered. However, the term "discharge point" can be defined with a great deal of flexibility, allowing the system to track individual waste sites or operable units with no difficulty. The HECR provides for entry of additional compliance status information for those points needing follow-up action. This is done to allow tracking of compliance actions on a specific point. The ECTS contains regulatory flowsheet information. It is designed to be used in the evaluation of waste streams for compliance with Federal, State, and local environmental regulations. Waste streams are the primary focus of the ECTS; however, waste streams can be defined with some flexibility to allow the system to be used to track individual waste sites or operable units. The HECR and ECTS can be used in the comprehensive DMS to track compliance status of operable units (or individual sites if conditions warrant).

The sample preparation system was set up to generate labels for sample bottles and to track sample status at the analytical laboratories. It can generate reports on samples collected, samples currently at an analytical laboratory, and samples with results overdue from the laboratory.

The Basalt Waste Isolation Project (BWIP) technical data system was being prepared to contain information on hydrological conditions and some geological data at the Hanford Site. The system was intended to handle data obtained from wells in hydrologic units in the basalt strata giving Lambert coordinates, water pressure, and other similar well information. It was also designed to handle site characterization, hydrological, hydrochemistry, stratigraphy, and constituent data. There is some overlap between the capabilities of the Hanford groundwater data base and the BWIP technical data system. The BWIP technical data system is not intended for shallow wells in the unconfined aquifer.

The warehouse inventory management system is a data base established to track, from receipt of material to its shipment to the customer, all stock items and to forward costing data to the financial data system. For the purpose of safe storage and transportation, hazardous materials are identified within the warehouse inventory management system. The system will be used in conjunction with the material safety data sheet system and the SARA Title III program.

The Flow Gemini--environmental information system, managed by the HEHF, is commonly referred to as the HEX system. It is set up to contain information associated with onsite monitoring of exposures to hazardous materials of Hanford workers. This system is in the process of being modified, so there is considerable flexibility to adjust it to accommodate the onsite monitoring needs of the environmental restoration program.

The Flow Gemini--occupational health information system (HEHF's medical information tracking system) contains the confidential employee medical evaluation and history information. The HEHF medical surveillance program

will need to be given directions from the HASP for each operable unit as to the specific elements that will need to be tracked for the specific individuals involved with its characterization. Once this is done, the medical information tracking system will contain all of this information.

The material safety data sheet system contains information on chemicals found at the Hanford Site. Currently, this is a manually operated system operated by HEHF; however, it is in the process of being computerized. The computerization effort is being done in coordination with the SARA Title III mandated "right-to-know" program at the Hanford Site.

The occupational radiation exposure data base system contains personnel respiratory protection fitting and qualifications, work restrictions, and radiation exposure information for all Hanford Site employees. Access to individual employee's records must be tightly controlled to comply with the Privacy Act of 1974.

The quality control blind standards data base contains information associated with quality control spiked samples, replicate sampling, and interlaboratory comparison results for the Hanford Site RCRA program. The data base is currently a manually tracked system, but is in the process of being computerized. It can quite readily be expanded to handle these type of data for the environmental restoration program as well.

The training records information system contains training records for Westinghouse Hanford employees. Currently it handles contractors to Westinghouse Hanford manually, but is in the process of being upgraded to handle these electronically. The training records information system can be adjusted to include all contractor personnel working on a particular operable unit.

The financial tracking system contains financial records for tracking and reporting on status of projects at Westinghouse Hanford. It is the system Westinghouse Hanford uses to track the financial aspects of all their projects. It has the capability of tracking projects by cost accounts and can provide status reports upon request.

Data management procedures are addressed in Chapter 4 of EPA guidance (1988a). The contents of Table 4-2 of Section 4.2.1.3, which provides an outline of the file structure necessary for a superfund site, were used as a list of elements necessary for a data management system. Table 8-3 shows a listing of these elements and a brief discussion of how the various components of the DMS will address them.

The previous discussions have addressed the existing systems that can be used to provide a historical basis for the RI/FS work. However, there are

Table 8-3. Analysis of Data Needs as Specified in the U.S. Environmental Protection Agency Draft Guidance Directive and Current Historical Hanford Site Data Bases. (Sheet 1 of 2)

File structure/data needs	Applicable data bases
Congressional Inquires and Hearings: Correspondence Transcripts Testimony Published hearing records	None available. These will have to be addressed by written procedures.
Discovery: Initial investigation Preliminary assessment Site inspection report Hazard ranking system data	Waste information data system and hanford inactive site survey. The Hanford inactive site survey contains hard copy files of the information used for performing the hazard ranking system/modified hazard ranking system evaluations of Hanford waste sites.
Remedial Planning: Correspondence Work plans for remedial investigation/feasibility study Remedial investigation/feasibility study reports Health and safety plan Quality assurance/quality control plan record of decision/responsiveness summary	The commitment control system is presently available to track correspondence. Health and safety plans and quality assurance/quality control plans will be included in each work plan that will be developed for each operable unit. The information pertinent to the development of the remedial investigation/feasibility study report will be tracked by the Hanford environmental information system using subordinate data bases such as the: Hanford groundwater data base, program data management system, waste information data system, Hanford inactive site survey, sample preparation system, BWNP technical data system, warehouse inventory management system, Flow Gemini--environmental information system, and quality control blind standards data base.
Remedial Implementation: Remedial design reports Permits Contractor work plans and progress reports U.S. Army Corps of Engineers agreements, reports, and correspondence	All of these items will be tracked by the data management system.
State and Other Agency Coordination: Correspondence Cooperative agreement/ superfund State contract Interagency agreements Memorandum of understanding with the State	Parts of these may be able to be tracked by the Hanford environmental compliance report. A record-file system is also currently being developed at the Hanford Site to track many of these items. These will be managed within the data management system.

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Table 8-3. Analysis of Data Needs as Specified in the U.S. Environmental Protection Agency Draft Guidance Directive and Current Historical Hanford Site Data Bases. (Sheet 2 of 2)

File structure/data needs	Applicable data-base system
Community Relations: Interviews Correspondence Community relations plan List of people to contract, e.g., local officials, civic leaders, environmental groups Meeting summaries Press releases News clippings Fact sheets Comments and responses Transcripts Summary of proposed plan Responsiveness summary	There is no known existing system at the Hanford Site available to electronically track community relations information. This information will be handled manually in accordance with the community relations plan with tracking added to the data management system.
Imagery: Photographs Illustrations Other graphics	The Hanford inactive site survey and associated files contain photographs and maps of sites. Also, the Hanford Environmental Information System will have graphic information system capabilities.
Enforcement: Status reports Cross-reference to any confidential enforcement files and the person to contact Correspondence Administrative orders	The Hanford environmental compliance report and environmental compliance tracking system will be used to contain the compliance status information by operable unit. Any administrative orders that are formally produced can also be tracked in the data management system designed to track formal documents.
Contracts: Site-specific contracts Procurement packages Contract status notifications List of contractors	Other than existing project management software systems currently available at the Hanford Site, there is no known electronic system presently available to track contract information such as this. This information can be handled manually by procedures or the data management system can track it.
Financial Transactions: Cross-reference to other financial files and the person to contact Contractor cost reports Audit reports	The financial operations for the cleanup of a Federal facility is different from the normal U.S. Environmental Protection Agency-funded superfund process. The financial information that needs to be tracked for compliance purposes can be tracked manually or by the data management system.

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several data management needs identified in Table 8-1 for which there is no currently operated or historical data base. These include the following:

- Geophysical (site-by-site basis)
- Soil column analytical data (site-by-site basis)
- Pilot- and bench-scale testing
- ARAR screening
- Cost tracking
- Calibration tracking
- Instrument coordination
- QA/QC tracking
- Field and laboratory notebook tracking
- Document tracking (both site-specific documents and guidance documents)
- Treatment/alternative screening
- Summarized/analyzed data (involves most of the raw data types).

The environmental data management plan to be prepared by March 31, 1989 will address these needs. Initial development of HEIS will focus on these needs in the order listed.

9.0 COMMUNITY RELATIONS PLAN

A community relations plan is currently being developed for the Hanford Site environmental restoration program. Because community relations activities are so interrelated among operable units, a decision was made to develop a single community relations plan that will have the capability to address specific individual concerns associated with each operable unit, but will still provide continuity and general coordination of all the environmental restoration program activities with regard to community involvement. The site-wide community relations plan discusses Hanford Site background information, history of community involvement at Hanford, and community concerns regarding the Hanford Site. It also delineates the community relations program that the DOE-RL, the EPA Region X Office, and Ecology will cooperatively implement throughout the cleanup of all the operable units at the Hanford Site. All community relations activities associated with the 1100 Area work plan will be conducted under this overall Hanford Site community relations plan.

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APPENDIX A
SITE DESCRIPTION

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SITE DESCRIPTION

1.0 INTRODUCTION

Appendix A provides a brief summary of available information on geology, hydrogeology, surface hydrology, meteorology, air quality, and ecology of the 1100 Area. Because relatively little site-specific information is available, the information presented below is based primarily on regional data and extrapolation from other areas on the Hanford Site.

2.0 GEOLOGY

The 1100 Area lies on an elongated north-south plateau at an elevation of approximately 400 ft above mean sea level, between the Yakima and Columbia Rivers, which are at elevations of approximately 370 ft and 340 ft, respectively. The land surface slopes generally to the southwest toward the Yakima River and to the east toward the Columbia River. The area is located on the southern extension of the Central Hanford Sand Plain, which is part of the central plains geomorphic unit of the Columbia Plateau. Southwest-to-northeast-trending longitudinal dunes extend up to or across the 1100 Area. The amplitude of most of the dunes is on the order of 10 ft. The dunes are locally active, but for the most part they have been stabilized by vegetation or have been reworked in grading and excavation for facilities.

The principal structural feature is the Pasco Basin (Fig. A-1), which is one of several sediment-filled basins in the Central Columbia Plateau. The sediments in the Pasco Basin, as well as of the entire Columbia Plateau, are underlain by the Miocene age Columbia River Basalt Group. The sediments overlying the basalts, from the basalts upward, include (1) the Ringold Formation, (2) glaciofluvial deposits of the Hanford formation, which include Pasco Gravels and Touchet Beds, and (3) surficial eolian sediments. Figure A-2 illustrates suprabasalt stratigraphy in the Pasco Basin. Direct evidence as to the depth, thickness, and characteristics of sediments and basalts beneath the 1100 Area is limited. The description presented below is based primarily on a log for a test well north of the Horn Rapids landfill and on extrapolation of geologic conditions from the 300 Area.

2.1 COLUMBIA RIVER BASALT GROUP

Basalts of the Columbia River Basalt Group are present below a depth of approximately 170 to 200 ft. Comprised of numerous basalt flows and interbedded sediments, the Columbia River Basalt Group extends more than 12,000 ft below the Hanford Site (DOE 1986).

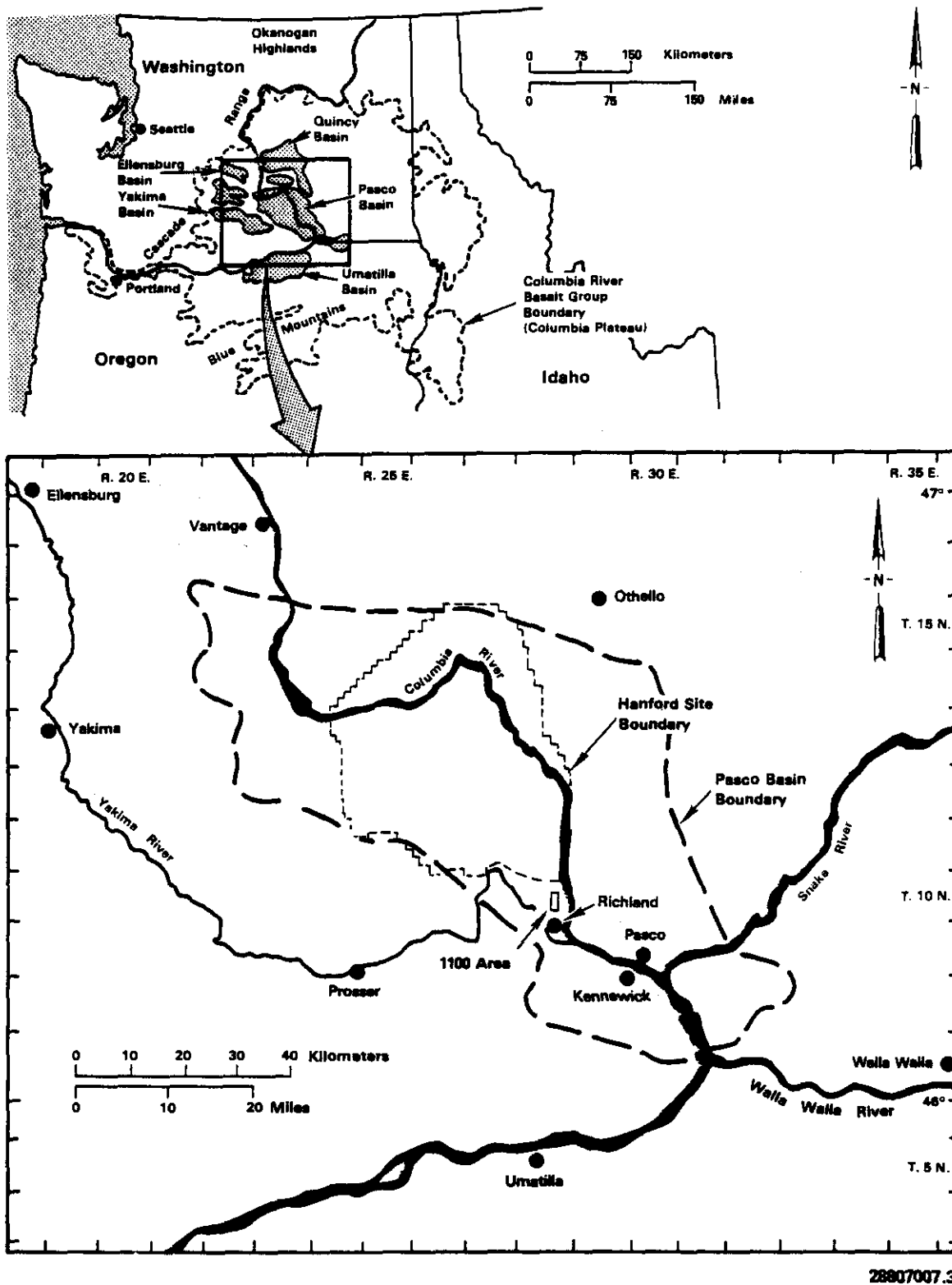
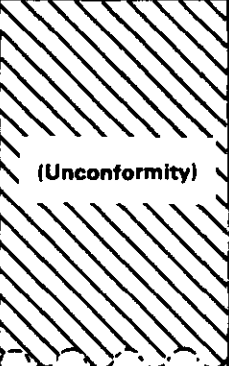



Figure A-1. Location of 1100 Area Within Pasco Basin.

Period	Epoch	Formation	Western Pasco Basin	300, 3000, 1100 Areas	Age (10 ⁸ yr)	
			Unit/Member			
Quaternary	Pleistocene	Hanford	Tochet Beds (mud and sand facies)	Tochet Beds (?)	0.013	
			Pasco Gravels? (sand and gravel facies)	Pasco Gravels		
Tertiary	Pliocene	Ringold	Unconformity		1.8	
			Paleosol			
			Fanglomerate Unconformity		(Unconformity)	
			Upper Ringold			
	Miocene	Ringold	Middle Ringold		5.3	
			Local Unconformity		Ringold (Undifferentiated)	
			Lower Ringold Unconformity		Gravels And Sands	
			Basal Ringold		Lower "Blue-clay" Member	
		Saddle Mountains Basalt	Unconformity			
			Elephant Mountain Member	Ice Harbor Member	8.5	

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Figure A-2. Suprabasalt Stratigraphy of the Pasco Basin.

2.2 RINGOLD FORMATION

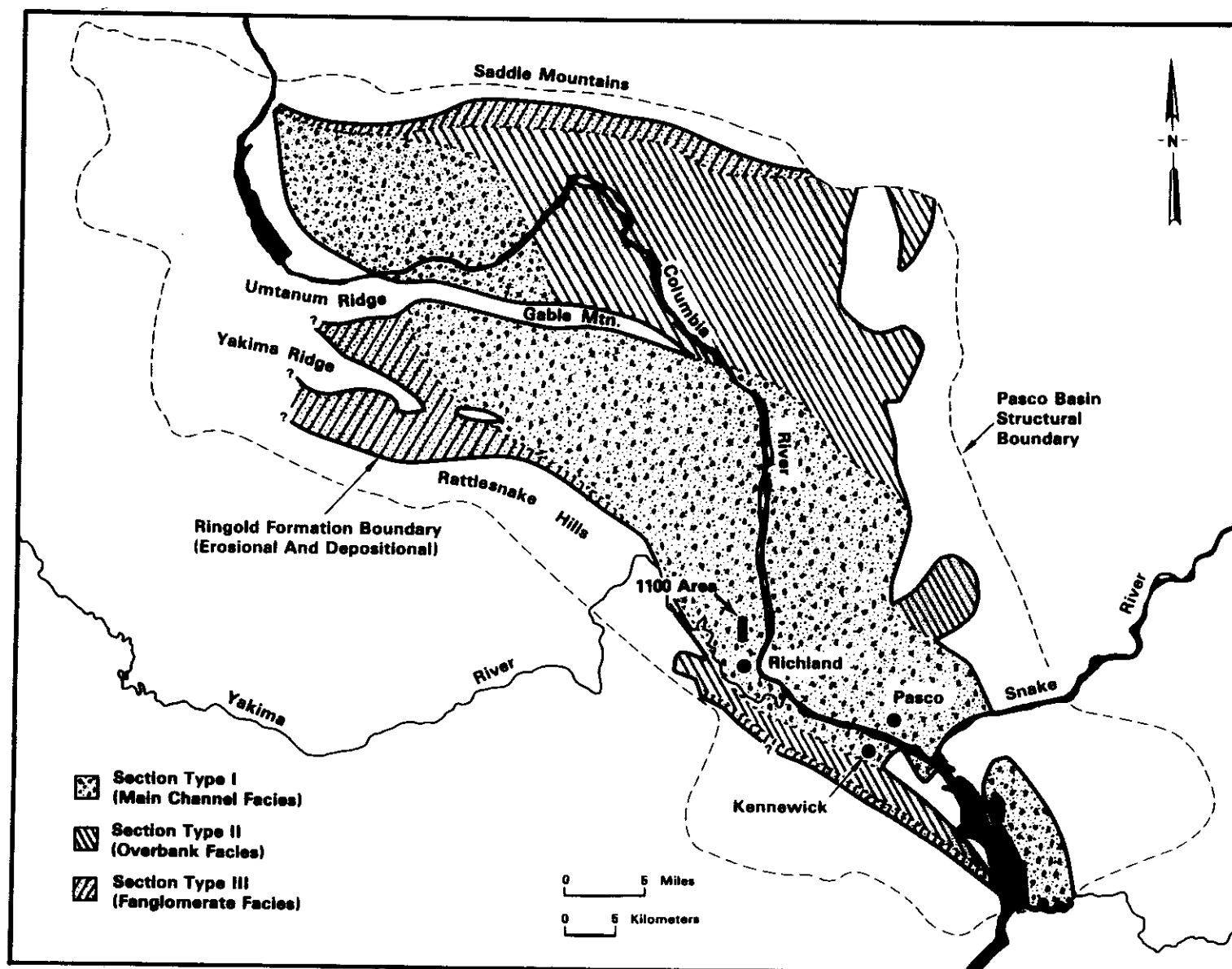
The Ringold Formation directly overlies the uppermost basalt flows of the Columbia River Basalt Group. The Ringold is a fluvial sedimentary unit that exhibits lateral facies variations. Major facies of the Ringold Formation include the main river channel facies, overbank facies, and conglomerate facies. Figure A-3 shows the general distribution of Ringold facies types within the Pasco Basin. Because of the facies variations and limited data, the stratigraphic relationship between Ringold units observed in the 3000, 300, and 1100 Areas and well-studied sections in the western Pasco Basin is not completely known.

Newcomb (1958) divided the Ringold Formation into three members, based on exposures at the type section along the southern end of the White Bluffs (located along the Columbia River at the east side of the Hanford Site). These are a "lower blue clay member," a "middle conglomerate member," and an "upper member." The "lower blue clay member" (now called the lower Ringold unit) is now known to overlie, in some areas of the Hanford Site, a thin basal Ringold unit composed of clayey to gravelly sand. The lower unit itself is generally a clay or silt that often contains sandy or gravelly layers (Newcomb et al. 1972). The middle Ringold unit is generally a sandy gravel with local sand or silt lenses. The upper Ringold unit, found mainly in the White Bluffs area to the north and across the Columbia River from the 300 Area, is composed mainly of fine sand and silt.

A complete section of the Ringold Formation is probably not present in the vicinity of the 1100 Area. In the 300 Area, approximately 2 mi north of the 1100 Area, the upper unit and part of the middle unit have been removed by erosion prior to deposition of the Pasco Gravels (Lindberg and Bond 1979). This is probably the case in the 1100 Area also. In the 1100 Area the lower Ringold unit (and the basal unit if present) lie completely beneath the water table. The water table lies within the uppermost portion of the Ringold Formation present (the middle Ringold unit) or within the lowermost portion of the Pasco Gravels. Total thickness of the Ringold Formation in a test well (10/29 - 10G1) approximately 0.5 mi north of the Horn Rapids landfill is approximately 144 ft (Newcomb et al. 1972). The lower 23 ft correspond to the "lower Ringold unit" discussed above, while the remaining thickness consists primarily of gravel, gravelly sand, sand, and silty sand, with occasional interbeds of clay and siltstone. In the 300 Area, the Ringold Formation present is approximately 150 ft thick with the lower Ringold unit about 40 ft (Lindberg and Bond 1979).

2.3 PASCO GRAVELS

Glaciofluvial deposits known as the Pasco Gravels overlie the Ringold Formation and extend to very near the surface. These gravels were deposited by Pleistocene floodwaters resulting from catastrophic failure of ice dams in



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Figure A-3. Distribution of Ringold Facies Types in the Pasco Basin.

western Montana and northern Idaho. The Pasco Gravels were deposited on an irregular erosional surface along main channelways of the catastrophic floods. Thickness of the gravels varies from 30 ft to more than 50 ft.

Touchet beds are rhythmically bedded, fine-grained slack water flood facies that are generally contemporaneous with the Pasco Gravels. Because the 1100 Area lies along a main flood channelway (Fig. A-4), Touchet beds are not expected to constitute a significant part of the stratigraphic section within the 1100 Area.

A total thickness of 47 ft for "glaciofluvial and fluvial deposits," corresponding to the Pasco Gravels is reported in well 10/28 - 10G1 (Newcomb et al. 1972). These deposits consist of sandy gravel with boulders, in which the predominant lithology of the gravel and boulders is generally basalt.

2.4 SURFICIAL EOLIAN SEDIMENTS

Eolian sands and silts cover the area as a veneer of varying thickness. These deposits consist of fine to medium sand or silty sand.

3.0 HYDROGEOLOGY

Groundwater beneath the area occurs in confined aquifers within the basalt sequence, the unconfined aquifer of the Pasco Gravels, and the sands and gravels of the Ringold Formation. The boundary between the confined and unconfined aquifers is typically the lowermost silt and clay member of the Ringold Formation (Lindberg and Bond 1979). A confined aquifer may exist in gravel layers beneath the silt/clay member and immediately above the basalt. The estimated depth to the water table in the vicinity of the 1100 Area is approximately 40 to 60 ft. Because of lateral facies variations, silt or clay lenses in the Ringold Formation may function as aquitards on a local scale. Perched or semiperched water conditions may also occur locally.

The unconfined aquifer in the area exhibits relatively high permeability, particularly in the Pasco Gravels. Aquifer pumping tests and numerical groundwater modeling for the 300 Area indicate transmissivities greater than 100,000 ft²/d (Lindberg and Bond 1979). The storativity of the unconfined aquifer has been estimated to be 0.1 for hydrologic studies of the 300 Area (Lindberg and Bond 1979). Aquifer tests conducted in the north Richland well field (ICF 1987) indicate a transmissivity of approximately 86,000 ft²/d, and storativity of 0.11. No measurements of these parameters or of the dispersive or retardation characteristics of these aquifers beneath the 1100 Area are available. However, available data suggest that hydrologic properties of the 1100 Area may be similar to those of the 300 Area.

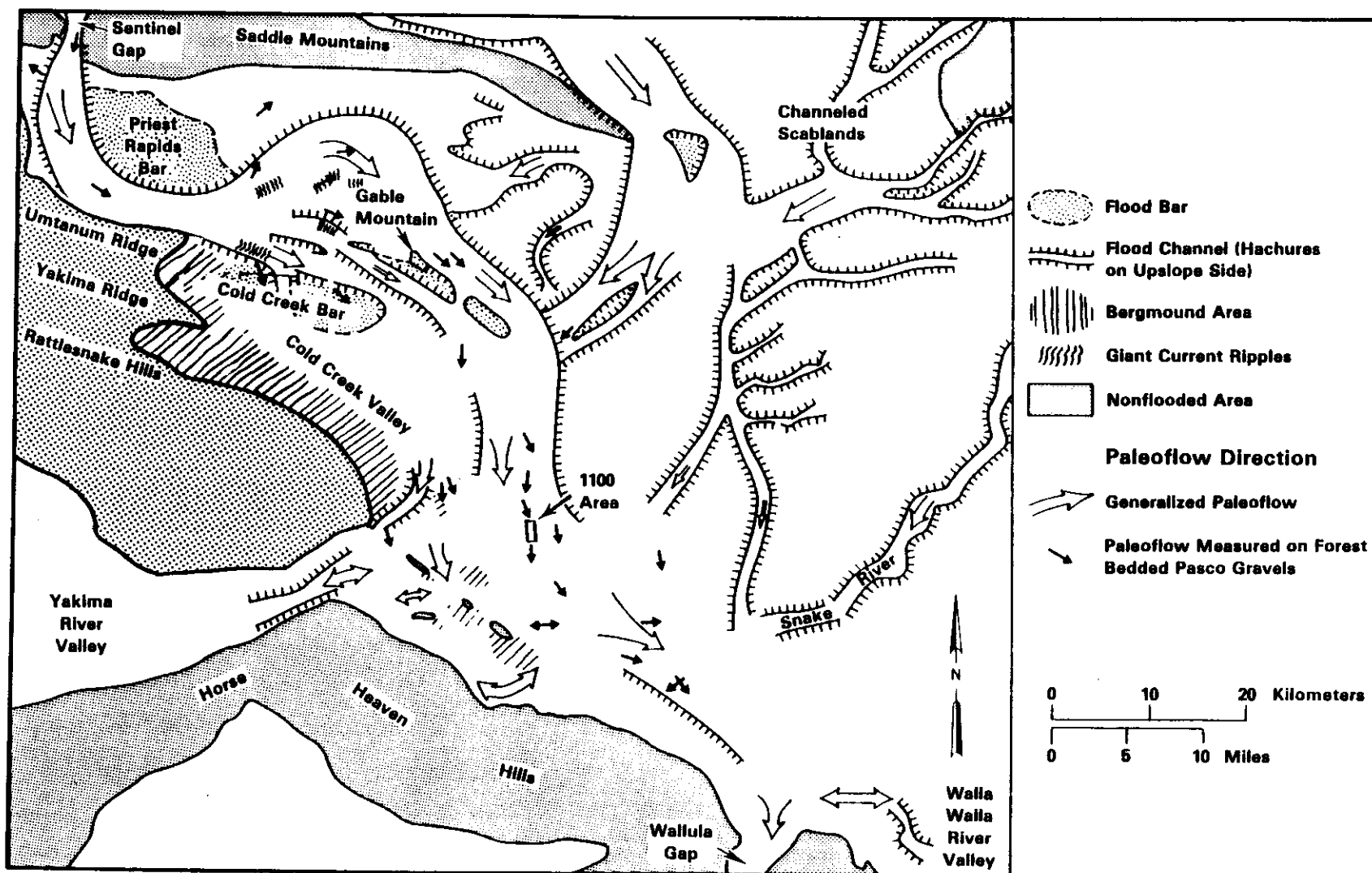


Figure A-4. Pleistocene Flood Channels.

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Water-table maps for the Hanford Site indicate that along the northern end of the 1100 Area, the water table dips to the east and ranges from approximately 370 to 350 ft above mean sea level (WHC 1987). Regional groundwater flow in the 1100 Area is thought to generally be west to east, controlled by the elevation difference between the Yakima and Columbia Rivers. The Yakima River is recharging the unconfined aquifer, which in turn discharges to the Columbia River. There are a number of factors that complicate this relatively simple system:

- Spatial differences in hydraulic conductivity of the unconfined aquifer
- The river stage of both the Yakima and Columbia Rivers
- Infiltration to the unconfined aquifer from irrigation
- Upward leakage (discharge) from the confined aquifer to the lower part of the unconfined aquifer
- Operation of the north Richland well field
- A water table that sometimes lies within the higher permeability Pasco Gravels and in other areas within the lower permeability Ringold Formation.

Of these factors, the operation of the north Richland well field is likely the most significant.

Halfway between the 1100 Area and the Columbia River is the city of Richland's north Richland well field. The wells are completed in the unconfined aquifer and are artificially recharged by water pumped from the Columbia River to infiltration ponds. Artificial recharge is conducted during the summer months and during the winter when the water treatment plant is shut down. The well field is used for city water-supply makeup during peak demand periods and when the water treatment plant is shut down for maintenance. Intermittent operation of the well field and recharge ponds likely causes significant local fluctuation of the water table and substantially affects the rate and direction of groundwater flow in the vicinity of the 1100 Area.

Given the heterogeneity of both the Pasco Gravels and the Ringold Formation, together with the various recharge/discharge points and seasonal variations in withdrawal, the groundwater flow conditions in the 1100 Area are likely to be complex, and direction and rate of groundwater flow is likely to change with time.

4.0 SURFACE HYDROLOGY

The major surface water features at the Hanford Site are the Columbia River, which is located approximately 1 mi east of the 1100 Area, and the Yakima River, about 2 mi to the west. Both streams are important sources of

industrial, agricultural, and domestic water for the region. Other streams in the vicinity of the 1100 Area are ephemeral. No surface water or ephemeral streams are present within the 1100 Area or the Horn Rapids landfill. Abandoned irrigation canals pass through the 1100 Area at several locations. These canals have not been used since the land was taken over by the U.S. Government in the 1940's.

Mean annual precipitation within the Pasco Basin ranges from less than 7 in. within the Hanford Site to a maximum of 15 in. atop Rattlesnake Mountain (located to the west-northwest of the 1100 Area). Total annual precipitation over the entire basin is estimated to be approximately 800,000 acre-ft, with an average annual precipitation of less than 8 in. Mean annual runoff is generally less than 0.5 in. for most of the basin (Leonhart 1979).

Average annual pan evaporation exceeds 60 in. Average annual lake evaporation ranges from 39 to 41 in. Actual evapotranspiration is essentially equivalent to annual precipitation (Leonhart 1979). Each of the individual sites in the 1100 Area is characterized by interior drainage, such that significant surface runoff is unlikely.

5.0 METEOROLOGICAL CONDITIONS AND AIR QUALITY

A comprehensive program of meteorological monitoring is in place at the Hanford Site. Meteorological data are collected at the Hanford Meteorological Station and at 24 automated monitoring stations (Fig. A-5) located within the Hanford Site and in adjacent areas. The Hanford Meteorological Station is located approximately 21 mi northwest of the 1100 Area, between the 200 East and 200 West Areas. Since 1945, meteorological measurements have been made at the station and at multiple levels on its 400-ft instrumented tower. Earlier measurements of temperature and precipitation, beginning in 1912, were made at the old Hanford townsite. A summary of these data, through 1980, has been published by Stone et al. (1983).

Two of the automated stations in the meteorological monitoring network are located within close proximity to the 1100 Area. These monitoring sites have been in operation since early 1982. The 300 Area monitoring site is located less than 1 mi north-northeast of the Horn Rapids landfill and approximately 3 mi north of the 1171 Building. At this station, measurements of wind direction and speed and of air temperature are made at three levels on a 200-ft meteorological tower. A doppler acoustic sounder is also located at this site. The sounder remotely senses wind directions and speeds, air temperatures, and other parameters to a height of up to 1,800 ft above the surface.

The second of these two stations is located about 2 mi to the south-southwest of the 1100 Area at the Richland Airport. At this monitoring site, wind and temperature sensors are mounted on the top of the airport's air-traffic control tower. Measurements are made at a height of approximately 50 ft above ground level.

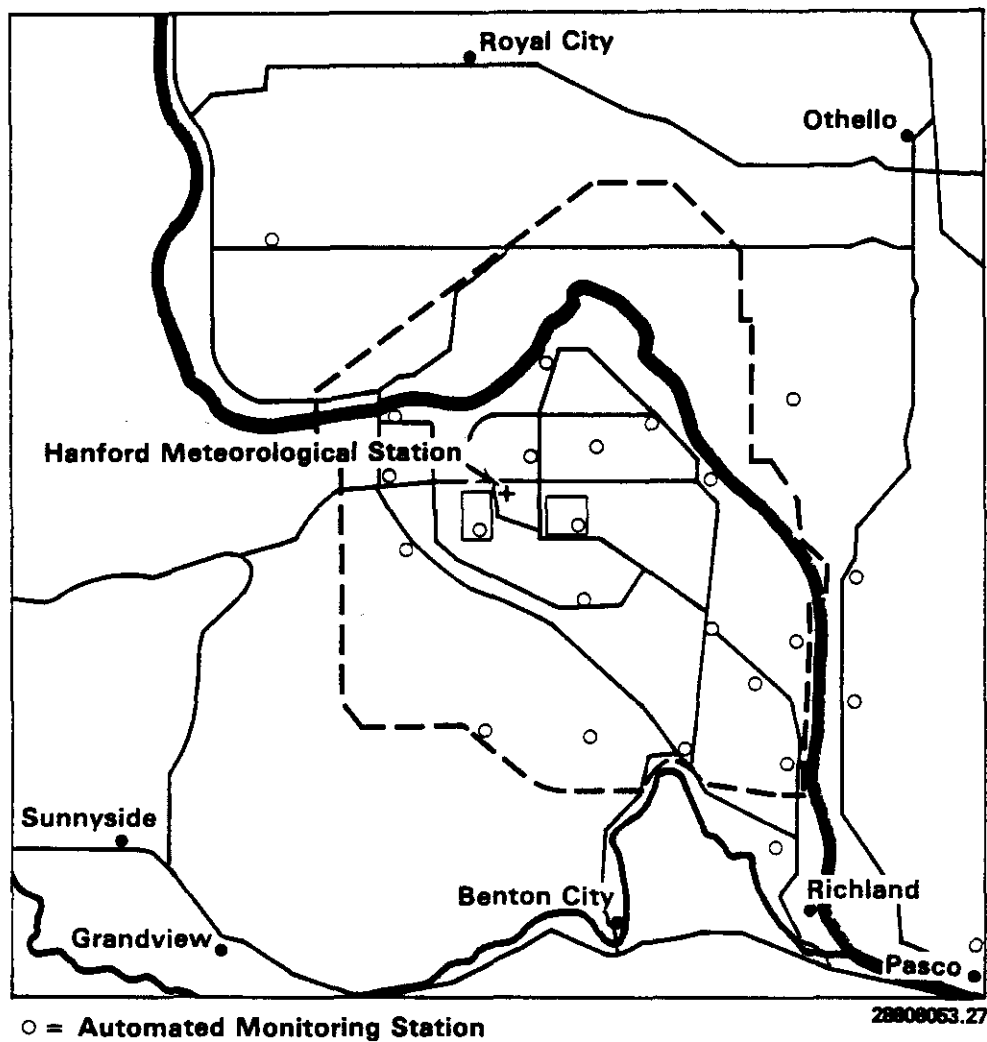


Figure A-5. Location of the Hanford Meteorological Station and Automated Monitoring Stations on the Hanford Site and in the Surrounding Area.

Meteorological data collected at the automated stations are communicated by radio to the Hanford Meteorological Station in the form of 15-min averaged values. After being received at the Hanford Meteorological Station, data are processed and stored on a minicomputer for later analysis.

5.1 NEAR-SURFACE WINDS

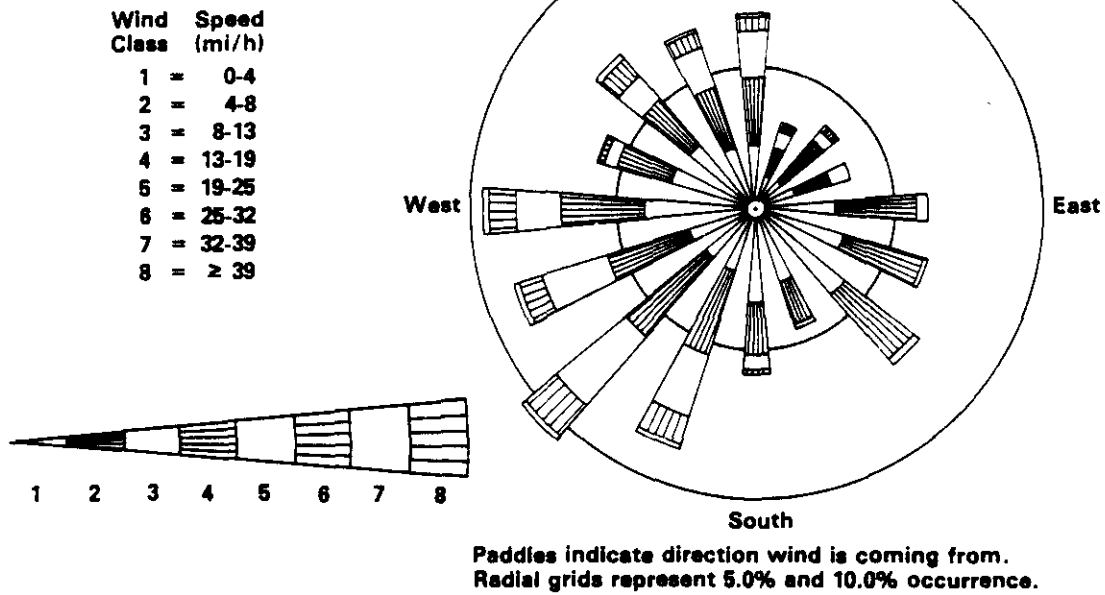
At the 300 Area site, the winds are most frequently out of the north, although winds from the southeast through the southwest also occur fairly frequently. At the Richland Airport site, the winds are most frequently from the southwest; winds from the west, west-southwest, and south-southwest are next in order of frequency. At both sites, winds with an easterly component tend to have significantly lower wind speeds than winds with a westerly component. Also at both sites, winds with the highest speeds tend to be from the southwest. Wind roses for both sites are presented in Figure A-6.

There are some significant differences in the wind patterns for the 300 Area and Richland Airport monitoring sites. These differences arise because of the influence of local terrain, vegetation, and nearby buildings on winds. The 300 Area site is located on a slight rise (a stabilized sand dune) less than 1 mi west of the Columbia River. The site is located in a north-south running river valley; the terrain to the west begins a gradual increase in elevation a little over 1 mi from the site, and the terrain to the east rises steeply on the east bank of the Columbia River. This terrain configuration should account for the high percentage of low speed winds with strong northerly and southerly components at the 300 Area station.

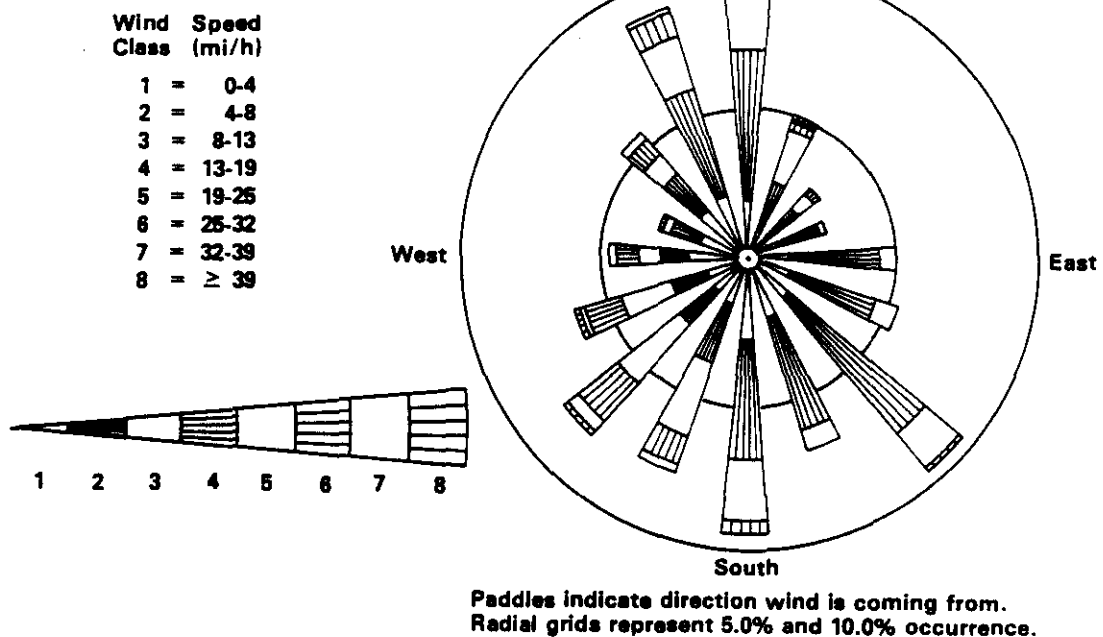
Measurements of the wind at the Richland Airport site are made at a slightly higher distance above the ground than at the 300 Area site. Airport buildings, of comparable height to the control tower, are located to the southwest of the wind sensors. The northwestern edge of the city of Richland and its surrounding shelterbelt of trees approach to within 1,000 ft of the site. The airport buildings and the city's trees and buildings should have some affect on the meteorology of this site. However, at the airport there are no significant variations in the elevation of the local terrain to influence winds, as at the 300 Area site.

The Horn Rapids landfill is located in the same general terrain environment as the 300 Area monitoring site; meteorological conditions at this disposal site should be adequately represented by measurements at the 300 Area station. The other disposal sites in the 1100 Area are located further to the south, between the Richland and 300 Area stations. Therefore additional meteorological monitoring will be required to determine how representative the existing meteorological monitoring sites are of conditions in the central and southern portions of the 1100 Area.

Wind Rose For Richland Airport



Wind Rose For 300 Area



28806063.21

Figure A-6. Wind Roses for Richland Airport and the 300 Area.

5.2 TEMPERATURE AND HUMIDITY

Diurnal and monthly averages and extremes of temperature, dewpoint, and humidity are contained in Stone et al. (1983). For the period 1912 through 1980, the average monthly temperatures range from a low of 29.3 °F in January to a high of 76.4 °F in July. During the winter, the highest monthly average temperature at the Hanford Meteorological Station was 44.5 °F, and the record lowest was 21.4 °F; both occurred during February. During the summer, the record maximum monthly average temperature was 81.8 °F in July, and the record low was 63.0 °F in June. The annual average relative humidity at the Hanford Meteorological Station is 54%, with maxima during the winter months (averaging around 75%) and minima during the summer (about 35%).

5.3 PRECIPITATION

Average annual precipitation at the Hanford Meteorological Station is 6.3 in. Most of the precipitation takes place during the winter, with nearly half of the annual amount accruing in the months of November through February. Days with greater than 0.5 in. precipitation occur less than 1% of the year. Rainfall intensities of 0.2 in/h persisting for 1 h are expected once every 10 yr. Rainfall intensities of 1 in/h for 1 h are expected only once every 500 yr. Winter monthly average snowfall ranges from a minimum of 0.3 in. in March to a maximum of 5.3 in. in January.

5.4 ATMOSPHERIC DISPERSION

Atmospheric dispersion is a function of wind speed, atmospheric stability, and mixing depth. Dispersion conditions are generally good when winds are moderate to strong, when the atmosphere is neutral or unstably stratified, and when there is a deep mixing layer. Good dispersion conditions associated with neutral and unstable stratification exist about 57% of the time during the summer. Less favorable dispersion conditions occur when the wind speed is light and the mixing layer is shallow. These conditions are most common during the winter, when moderately to extremely stable stratification exists about 66% of the time.

Occasionally there are extended periods of poor dispersion conditions that are associated with stagnant air in stationary high-pressure systems. Stone et al. (1972) estimated the probability of extended periods of poor dispersion conditions. The probability of an inversion period extending more than 12 h varies from a low of about 10% in May and June to a high of about 64% in September and October. These probabilities decrease rapidly for durations greater than 12 h.

5.5 AIR QUALITY

Sulfur dioxide, nitrogen dioxide, carbon monoxide, and total suspended particulates have been periodically monitored in the communities and commercial areas southeast of the Hanford Site, and/or sites within the Hanford Site, during the past two decades. The maximum ambient concentrations measured in the region are presented in Table A-1. Because these measurements were taken near local sources of pollution and during periods when pollutant emission rates were higher than current levels, these values are estimated to be higher than current maximum background concentrations.

Currently, air concentrations of nitrogen dioxide and total suspended particulates are routinely monitored on the Hanford Site. This monitoring indicates that the maximum annual average concentrations of nitrogen dioxide are less than 15 $\mu\text{g}/\text{m}^3$. Local monitoring of total suspended particulates for the Tri-County Air Pollution Control Board is conducted at the Hanford Meteorological Station. State-wide monitoring indicates that the concentrations of total suspended particulates periodically reach relatively high levels in eastern Washington, due to natural events (i.e., dust storms, sand storms, volcanic eruptions, and large brush fires). Accordingly, high levels of total suspended particulates have been measured at the Hanford Meteorological Station during such events. "Rural fugitive dust" from such natural events is typically exempted from regulatory consideration.

6.0 BIOTA

6.1 VEGETATION

The natural vegetation of the gently sloping land between the Rattlesnake Hills and the western shore of the Columbia River is dominated by desert shrubs, especially big sagebrush, bitterbrush, rabbitbrush, and, to a lesser degree, spiny hopsage. The herbaceous understory to the shrubs is mostly dominated by grasses, especially cheatgrass (an alien annual species introduced to eastern Washington from Eurasia in the late 1800s) and the small native bunchgrass, Sandberg bluegrass. The invasion of cheatgrass has been attributed to the effects of livestock grazing for many decades before 1943 (Mack 1981). The predominant vegetation type on land areas affected by waste management activities is the sagebrush-cheatgrass (*Artemisia tridentata* - *Bromus tectorum*).

The abandoned agricultural fields have been dominated by alien annual plants, such as cheatgrass and Russian thistle, for four decades, with little evidence of invasion by the native perennial plants.

Table A-1. Ambient Air Quality Standards and Maximum Measured Background Concentrations for the Hanford Site and the Surrounding Area ($\mu\text{g}/\text{m}^3$).

Concentration monitored	National primary standard	National secondary standard	Supplemental state standard	Maximum ambient concentration
Nitrogen dioxide				
Annual arithmetic mean	100	100	--	36
Sulphur dioxide				
Annual arithmetic mean	80	80	52	0.5
24-h maximum ^a	365	365	260	6
3-h maximum ^a	--	1,300	--	20
1-h maximum ^a	--	--	1,018	49
1-h maximum ^b	--	--	655	49
Carbon monoxide				
8-h maximum ^a	10,000	10,000	--	6,500
1-h maximum ^a	40,000	40,000	--	11,800
Total suspended particles				
Annual geometric mean	75	60	40 + bkgd. ^c	55/20 ^d
24-h maximum ^a	260	150	120 + bkgd. ^c	353/30 ^d

^aNot to be exceeded more than once per year.

^bNot to be exceeded more than two times in any consecutive 7 d.

^cbkgd. = background concentration caused by natural sources.

^dThe higher values represent concentrations caused by the occurrence of exceptional natural events (i.e., duststorms, brushfires). In the absence of duststorms and other natural events, the maximum annual background concentration would generally not exceed $20 \mu\text{g}/\text{m}^3$ and the maximum 24-h background concentration would generally not exceed $30 \mu\text{g}/\text{m}^3$. For siting and enforcement purposes, the U.S. Environmental Protection Agency uses these lower values for eastern Washington.

6.2 TERRESTRIAL ANIMALS

The most extensive terrestrial animal habitat on the Hanford Site is the sagebrush-grass habitat type. The game mammals on the Hanford Site are the mule deer, cottontail, and jackrabbit. The fur-bearers are the coyote, badger, and bobcat.

Resident small mammals include the Great Basin pocket mouse, deer mouse, Townsend ground squirrel, pocket gopher, harvest mouse, house mouse, Norway rat, sagebrush mole, grasshopper mouse, vagrant shrew, least chipmunk, and Merriam shrew.

The game birds that may nest in the sagebrush-grass habitat type are the sage grouse, mourning dove, chukar partridge, and gray partridge. Hawks and owls use the Hanford Site as a refuge, especially during nesting (Fitzner et al. 1980). Raptors that nest on the Hanford Site include Swainson's hawk, red-tailed hawk, northern harrier, kestrel, prairie falcon, burrowing owl, and great horned owl.

Historically, the sagebrush-grass habitat has provided breeding sites for small birds and animals such as the horned lark, western meadowlark, and the Great Basin pocket mouse. An ever expanding use of land for irrigated agriculture, dryland wheat crops, and urbanization has resulted in substantial loss of sagebrush-grass habitat in eastern Washington. Although the land of the Hanford Site has not experienced the dramatic loss of sagebrush-grass habitat that has steadily occurred on the surrounding lands over the past four decades, some species of animals and plants that were abundant in sagebrush-grass habitats in the past have diminished in abundance to the point where they may in the near future become extirpated or extinct. Some species may require special kinds of management. Endangered and threatened plants and animals (as designated by both Federal and State of Washington agencies) that occur or are thought to occur on the Hanford Site are briefly reviewed in Tables A-2 and A-3.

Table A-2. Endangered, Threatened and Sensitive Plants on the Hanford Site.

Taxa	Status ^a	Relationship to the 1100 Area
Columbia Milk Vetch <i>Astragalus columbianus</i> Barneby	Threatened C ^b	A local endemic with its major populations located on the Yakima Firing Center; not expected to occur in the vicinity of the 1100 Area
Persistent Sepal Yellowcress <i>Rorippa columbiae</i> Suksd. ex Howell	Endangered C	Known to occur on the wetted shoreline of the Columbia River on the Hanford Site; not likely to occur in the vicinity of the 1100 Area
Thompson's Sandwort <i>Arenaria franklinii</i> Dougl. var. <i>Thompsonii</i> Peck	Threatened	Exists as <i>A. franklinii</i> on stabilized sand dunes; taxonomic status is currently under consideration
Hoover's Desert Parsley <i>Lomatium tuberosum</i> Hoover	Threatened C	A local endemic in Yakima, Benton, Grant, and Kittitas Counties, occurrence in the vicinity of the 1100 Area has not been established
Gray Cryptantha <i>Cryptantha leucophea</i> Dougl. Pays	Sensitive	Occurs on stabilized sand dunes of the Hanford Site near the Wye Barricade; occurrence in the vicinity of the 1100 Area has not been established
Piper's Daisy <i>Erigeron piperianus</i> Cronq.	Sensitive	A local endemic, occurs on the Arid Lands Ecology Reserve; occurrence in the vicinity of the 1100 Area has not been established
Tooth-Sepal Dodder <i>Cuscuta denticulata</i> Engelm.	Monitor	Recently found in Benton County; parasitic on sagebrush; may occur in the vicinity of the 1100 Area

^a Definitions of special classifications of vascular plants in Washington and special terminology:

Endangered--A vascular plant taxon in danger of becoming extinct or extirpated in Washington within the near future if factors contributing to its decline continue. These are taxa whose populations are at critically low levels or whose habitats have been degraded or depleted to a significant degree.

Threatened--A vascular plant taxon likely to become endangered within the near future in Washington if factors contributing to its population decline or habitat degradation or loss continue.

Sensitive--A vascular plant taxon, with small populations or localized distribution within the state, that is not presently endangered or threatened, but whose populations and habitats will be jeopardized if current land use practices continue.

Monitor--A vascular plant taxon of potential concern because of uncertain taxonomic status or paucity of information concerning distribution; or a taxon that is actually more abundant or less threatened than previously thought.

^bPlants that are listed as "C" are candidates on the 1980 Federal Register Notice of Review and 1983 Supplement.

^cLocal endemic--A taxon restricted to a geographical area, usually within a single county or several adjacent counties.

Table A-3. Endangered, Threatened, and Sensitive Animals on the Hanford Site. (Sheet 1 of 3)

Taxa	Status ^a	Relationship to the 1100 Area
WASHINGTON STATE STATUS OF SPECIAL BIRD SPECIES		
Birds Associated with Dryland Habitats of the Hanford Site But Not Known to Nest on the Hanford Site		
Golden Eagle <i>Aquila chrysaetos</i>	PS	Forages in sagebrush-grass habitats; mostly a winter visitor
Birds that are Infrequent Visitors to the Hanford Site		
Peregrine Falcon ^b <i>Falco peregrinus</i>	SE	An erratic visitor
Birds Associated with Sagebrush-Grass Habitats		
Ferruginous Hawk <i>Buteo regalis</i>	ST	An occasional forager in sagebrush-grass habitats; an occasional nester on the Arid Lands Ecology Reserve
Swainson's Hawk <i>Buteo swainsonii</i>	PS	Forages in sagebrush-grass habitats in spring and summer
Prairie Falcon <i>Falco mexicanus</i>	PS	Forages in sagebrush-grass habitats; a year-round resident
Burrowing Owl <i>Athene cunicularia</i>	PS	Forages in sagebrush-grass habitats
Sage Thrasher <i>Oreoscoptes montanus</i>	PS	A possible forager in sagebrush-grass habitats
Long-Billed Curlew <i>Numenius americanus</i>	PM	Nests in dryland habitats in the vicinity of the 1100 Area, mostly in spring and summer; forages in sagebrush-grass habitats
Sage Sparrow <i>Amphispiza belli</i>	PM	Nests in desert shrubs; forages in sagebrush-grass habitats in spring and summer
Sage Grouse <i>Centrocercus urophasianus</i>	c	A small population inhabits the Arid Lands Ecology Reserve
WASHINGTON STATE STATUS OF SPECIAL MAMMAL SPECIES		
Pygmy Rabbit <i>Sylvilagus idahoensis</i>	ST	An unlikely inhabitant of sagebrush-grass habitats in the 1100 Area; may be extirpated from the Hanford Site
Merriam's Shrew <i>Sorex merriami</i>	PS	An unlikely inhabitant of sagebrush-grass habitats in the 1100 Area; known to inhabit the Arid Lands Ecology Reserve
White-Tailed Jackrabbit <i>Lepus townsendii</i>	PS	An unlikely inhabitant of sagebrush-grass habitats in the 1100 Area; may be extirpated from the Hanford Site

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Table A-3. Endangered, Threatened, and Sensitive Animals on the Hanford Site. (Sheet 2 of 3)

Taxa	Status ^a	Relationship to the 1100 Area
WASHINGTON STATE STATUS OF SPECIAL MAMMAL SPECIES		
Sagebrush Vole <i>Lagurus curtatus</i>	PM	An unlikely inhabitant of the sagebrush-grass habitats in the vicinity of the 1100 Area; more abundant on the Arid Lands Ecology Reserve
Northern Grasshopper Mouse <i>Onychomys leucogaster</i>	PM	Present in sagebrush-grass habitats
Ord Kangaroo Rat <i>Dipodomys ordii</i>	PM	Not known to inhabit the Hanford Site
Townsend Ground Squirrel <i>Spermophilus townsendii</i>	PM	Locally abundant in sagebrush-grass habitats
Several species of bats may inhabit abandoned buildings. The Long-Eared Myotis (<i>Myotis evotis</i>) and Pallid Bat (<i>Antrozous pallidus</i>) are listed as PS. The Yuma Myotis (<i>Myotis yumanensis</i>), Fringed Myotis (<i>M. thysanoides</i>), Long-Legged Myotis (<i>M. volans</i>), Small-Footed Myotis (<i>M. leibi</i>), and Western Pipistrelle (<i>Pipistrellus hesperus</i>) are listed as PM. The Townsend's Big-eared Bat (<i>Plecotus townsendii</i>) is listed as PT.		
WASHINGTON STATE STATUS OF SPECIAL REPTILE AND AMPHIBIAN SPECIES		
Sagebrush Lizard <i>Sceloporus graciosus</i>	PM	Known to inhabit sagebrush-grass habitats
Northern Desert Horned Lizard <i>Phrynosoma platyrhinos</i>	PM	Known to inhabit sagebrush-grass habitats
Striped Whipsnake <i>Masticophis taeniatus</i>	PM	May be present in sagebrush-grass habitats
Night Snake <i>Hypsiglena torquata</i>	PM	May be present in sagebrush-grass habitats
WASHINGTON STATE STATUS OF SPECIAL INVERTEBRATE SPECIES		
Oregon Swallowtail butterfly <i>Papilio oregonius</i>	PM	Inhabits sagebrush-grass habitats; ecological status in the vicinity of the 1100 Area is unknown

^aDefinitions of some special classifications of animal species:

State Endangered (SE)--A species that is seriously threatened with extirpation within the State of Washington. These are classified by the State Game Commission as endangered wildlife (WAC 232-12-014). Protected from taking due to damage (RCW 77.1.265).

Proposed Endangered (PE)--A species proposed for consideration for State Endangered classification.

State Threatened (ST)--A species that could become endangered without management or removal of threats. These species are classified by the State Game Commission as protected wildlife (WAC 232-12-011). Protected from possession, control, or destruction of nests or eggs (RCW 77.16.120).

Proposed Threatened (PT)--A species proposed for consideration for State Threatened classification.

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**Table A-3. Endangered, Threatened, and Sensitive Animals
on the Hanford Site. (Sheet 3 of 3)**

State Sensitive (SS)--A species that could become Threatened if current water, land, and environmental practices continue. Classified by the State Game Commission as Protected Wildlife and protected from possession, control, or destruction of nests or eggs.

Proposed Sensitive (PS)--A species proposed for consideration for State Sensitive classification.

Monitor Species (SM)--A species of special interest because of public appeal, need for special habitats during a portion of their life cycle, status as indicators of environmental quality, population status that is mostly unknown, taxonomic status in need of further study, or justifiably removed from Endangered, Threatened or Sensitive classifications.

Proposed Monitor (PM)--A species proposed for State Monitor classification.

^bFE = Federally designated endangered species.

^cUndetermined.

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APPENDIX B
EXISTING OPERABLE UNIT DATA

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APPENDIX B

EXISTING OPERABLE UNIT DATA

1.0 INTRODUCTION

Limited data specific to waste disposal operations and groundwater conditions in the 1100-EM-1 operable unit and vicinity are available. Existing data include the following:

- Analyses by the State of Washington of well-head water from the Richland, north Richland, and Duke well fields
- Analyses by Hanford Environmental Health Foundation (HEHF) of well-head water from the north Richland well field
- Analyses of eight preliminary surface soil samples
- Analyses of water samples from 11 wells in the 1100 and 3000 Areas and vicinity
- Analyses of water samples from seven wells in the vicinity of the 1100 Area conducted in August 1988 by the Hanford site-wide groundwater monitoring project.

Results of these analyses will be discussed in terms of water analyses for the north Richland and Duke wells, water analyses for 1100 and 3000 Area groundwater monitoring wells, and analyses of preliminary soil samples.

2.0 WATER ANALYSES FOR THE NORTH RICHLAND AND DUKE WELL FIELDS

The State of Washington Department of Social and Health Services, Division of Health, Public Health Laboratories analyzed a sample from the north Richland well field and one from the Duke well field. A total of 54 compounds were analyzed using U.S. Environmental Protection Agency (EPA) Method 524 (EPA 1986a). In the sample from the north Richland well field, the only compounds detected were chloroform, [13.6 parts per billion (p/b)] and bromodichloromethane (1.5 p/b). In the sample from the Duke well field, the only compound detected was chloroform, 1.6 µg/L. Other samples from the Richland water supply system showed similar results. Results of these analyses are available from the city of Richland.

Samples taken in August 1987 from the north Richland well field and analyzed by HEHF show results that are generally consistent with the results obtained by the State of Washington. Well D-5 on the north end of

the north Richland well field showed 2.2 µg/L chloroform. No other hydrocarbon compounds out of 36 analyzed were detected above the minimum detection limit of 0.5 µg/L. Well 3000-B showed 1.73 µg/L chloroform, 0.73 µg/L bromoform, and 0.7 µg/L p-chlorotoluene. (The p-chlorotoluene may be an artifact according to the analyst.)

These two samples were also analyzed for a variety of metals and anions important to water quality. The results for constituents above detection levels are as follows. Well D-5: nitrate, 0.32 mg/L; sodium, 2.9 mg/L; chloride, 1.3 mg/L; sulphate, 10.0 mg/L; and total dissolved solids (TDS), 107 mg/L. Well 3000-B: nitrate, 0.67 mg/L; sodium 2.5 mg/L, chloride, 1.0 mg/L; sulphate, 9.3 mg/L; and TDS, 94 mg/L.

Chloroform, bromoform, and bromodichloromethane are all compounds that can be associated with the chlorination process for city water supplies or with sewage treatment processes. However, these samples were taken at the well head, so these compounds did not result directly from chlorination of Richland city water. Possible explanations of their origin include irrigation of lawns with chlorinated city water and subsequent infiltration of the water into the unconfined aquifer and/or the introduction of chlorinated water to the Yakima and/or Columbia Rivers through irrigation runoff or sewage disposal practices. A one-time sampling of Columbia River water at the 300 Area intake showed none of the chlorination-related compounds.

Similar chlorination-related compounds have been detected in well-head samples from the Vernita rest area, the Wellsian Way well field, and in finished effluent from the Richland sewage treatment plant (37 µg/L). The Vernita rest area is upstream from the Hanford Site approximately 34 mi northwest of the 1100 Area. The Wellsian Way well field is located in the southern part of Richland approximately 4 mi south of the 1100 Area. It is unlikely that either of these areas has been affected by contamination from the 1100 Area, nor is there any indication that the 1100 Area is a potential source of chloroform and related compounds. Therefore, the trace levels of chlorination-related compounds in the north Richland and Duke well fields are not likely to be from the 1100 Area. Instead, the ubiquitous nature of the chlorination-related compounds suggests that they are characteristic of shallow aquifers recharged from the Yakima or Columbia Rivers. Alternatively, they may be the result of irrigation by chlorinated water.

Given the previous discussion, no evidence of contamination of the north Richland and Duke well fields from the 1100-EM-1 operable unit has been detected to date based on direct analysis of the water from the well fields.

3.0 RELIMINARY SURFACE SOIL SAMPLES

Eight preliminary surface soil samples were taken in March 1988 at the battery acid pit (1100-1), paint and solvent disposal site (1100-2), antifreeze and degreaser pit (1100-3), a possible spill located 800 m north of the 1171 Building and west of the shops (the "discolored-soil site"), and from the asphalt emulsion on the large sand hill immediately north of the 1171 Building. Results from these samples are shown in Table B-1.

Table B-1. Analytical Results for Surface Soil Samples from the 1100 Area.
(Sheet 1 of 2)

Constituent (µg/g)	Battery acid pit (1100-1) BAP001A01	Battery acid pit (1100-1) BAP001B01	Spill west of tracks SWT001A01	Asphalt emulsion AEP001A01	Paint and solvent pit (1100-2) 110002A01	Paint and solvent pit (1100-2) 1100002B01	Antifreeze and degreaser pit (1100-3) 110003A01	Antifreeze and degreaser pit (1100-3) 110003B01
ALPHA (pCi/L)	<1.4	5.3	4.2	3.9	4.3	2.6	<2.2	<0.9
BETA (pCi/L)	18.1	20.9	17.3	20.5	16.7	16.8	15.3	14.0
Hg	1.37	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Be	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sr	35	22	18	16	24	21	25	22
Zn	77	58	97	92	46	49	45	47
Ca	11,700	4,520	3,250	4,830	5,130	4,570	9,640	7,530
Ba	91	75	82	57	71	65	72	64
Cd	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cr	12	15	10	9	8	9	7	4
Ag	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Na	849	279	132	047	311	287	253	307
Ni	9	6	9	9	9	9	7	5
Cu	<1.0	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
V	47	58	52	59	58	52	58	60
Sb	<10	<10	<10	<10	<10	<10	<10	<10
Al	1,000	5,710	7,310	5,820	7,710	7,260	6,680	4,970
Mn	276	207	309	270	301	287	290	296
K	1,590	1,230	1,460	786	1,220	1,200	1,300	686
Fe	26,300	25,300	23,800	23,400	25,400	23,700	26,600	28,000
Mg	5,150	4,000	4,790	4,980	5,160	4,990	5,020	4,780
As	4.0	1.2	0.95	1.2	0.9	1.3	0.9	<0.5
Se	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pb	980	1,140	21.4	56.4	20.8	28.4	5.5	4.1
Nitrate	1.6	3.9	<1.0	<1.0	11	5.8	10.5	1.3
Sulfate	1,650	1,510	2.0	3.4	21.2	5.2	5.4	<1.0

Table B-1. Analytical Results for Surface Soil Samples from the 1100 Area.
(Sheet 2 of 2)

Constituent (µg/g)	Battery acid pit (1100-1) BAP001A01	Battery acid pit (1100-1) BAP001B01	Spill west of tracks SWT001A01	Asphalt emulsion AEP001A01	Paint and solvent pit (1100-2) 110002A01	Paint and solvent pit (1100-2) 1100002B01	Antifreeze and degreaser pit (1100-3) 110003A01	Antifreeze and degreaser pit (1100-3) 110003B01
Fluoride	2.9	3.9	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloride	1.9	<1.0	<1.0	<1.0	4.3	2.1	1.2	<1.0
Phosphate	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
TOX ^a	<1.0	<1.0	<1.0	4.0	<1.0	<1.0	<1.0	<1.0
TOC ^b	70.3	50.2	353	461	61.5	39.3	45.9	19.0
ETHYGLY ^c	<10	<10	<10	<10	<10	<10	<10	<10
AR1254 ^d	<1.0	1.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Unknown ABN ^e	ND	1.3	(e)	ND	ND	ND	ND	ND
BISPHT ^f	ND	ND	170	17	ND	ND	ND	ND
DINOPHT ^g	ND	ND	82	ND	ND	ND	ND	ND
Unk. Aliph.HC ^h	ND	ND	ND	(i)	ND	ND	ND	ND

^aTotal organic halogen.

^bTotal organic carbon.

^cEthylene glycol.

^dArochlor 1254 - polychlorinated biphenyl.

^eNine unknown acid-base-neutrals (ABN) with estimated concentrations of 26 to 2,900 µg/g.

^fBis(2ethylhexyl) phthalate.

^gDi-n-octyl phthalate.

^hUnknown aliphatic hydrocarbon

ⁱNine unknown aliphatic hydrocarbons with estimated concentrations of 22 to 36 µg/l.

ND = not detected.

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These samples were all surface samples intended to give a rapid indication of contamination to assist with development of the work plan. The samples show that the soils at the battery acid pit (1100-1) have elevated levels of lead and sulphate and possibly slightly elevated levels of mercury, chromium, and arsenic. One of the two battery acid pit samples contains measurable quantities of a polychlorinated biphenyl (PCB) (1.3 µg/g).

Samples from the paint and solvent pit (1100-2) and the antifreeze and degreaser pit (1100-3) did not indicate any evidence of contamination.

The sample from the apparent spill west of the tracks (discolored soil) contains measurable concentrations of two phthalates, nine acid-base-neutral (ABN) organics, and elevated total organic carbon (TOC).

The asphalt emulsion sample was taken to ensure that no hazardous substances were contained in the asphalt emulsion used to stabilize the large dune north of the 1171 Building. The sample contained constituents expected in an asphalt emulsion. No further action is planned for the asphalt emulsion.

4.0 PRELIMINARY WATER ANALYSES FROM 1100 AND 3000 AREA WELLS

Preliminary one-time sampling and water-level measurement of available 1100 and 3000 Area wells was conducted in the summer of 1986 by Pacific Northwest Laboratory (PNL) for the U.S. Department of Energy (DOE). The wells sampled had been drilled for a variety of purposes; some as early as 1943. The wells were not constructed as monitoring wells and have not been routinely sampled as part of the site-wide monitoring project.

The objective of the study was to make an initial assessment of the potentially hazardous constituents that may be present in the groundwater beneath the 1100 and 3000 Areas. Monitoring efforts were concentrated on the areas downgradient from the 1100 Area equipment maintenance facilities (Westinghouse Hanford Company) and the Kaiser Engineers construction facilities. Eleven wells were sampled (see Figure 2-1) between July 18 and 23, 1986. These data are presented in Table B-2. However, the scope of this study was limited, and caution should be exercised when using these data. These data should not be used to determine the water quality in the 1100 and 3000 Areas without additional sampling and research. Limitations noted during the study include the following: completion intervals for several of the wells were not known, three different sampling devices were used, all wells were sampled only once, and results were obtained from two separate analytical laboratories. The analytical results include data obtained by inductively coupled plasma, a method that has been known to yield unreliable results for some metals due to spectral interferences.

Of the 11 wells sampled, one (699-S36-13B) contained a large amount of sediment and yielded anomalous analytical results. The analytical results from this well are listed in Table B-2, but are not considered further and are not included in the generalizations that follow. A second well (ORV), located at the Off-Road Vehicle Park, includes multiple confined aquifers in its completion interval. Comparison of results from this well with other wells that tap only the unconfined aquifer may not always be appropriate.

Fluoride was detected in 6 of 10 wells, chloride in 10 of 10, nitrate in 8 of 10, and sulphate in 8 of 10. Phosphate was below detection limit [0.5 parts per million (p/m)] for all samples. Chloride was found in higher concentrations (>25 p/m) in the southern part of the study area (1100-D, 26 p/m and athletic complex well, 50 p/m). For the northern part of the study area (ORV, 699-S31-E13, and 699-S32-E13A wells), the range was 2.3 to 5.5 p/m. Concentrations in the 3000 group (3000-G, 3000-D, and 3000-N) ranged from 0.8 to 1.1 p/m, probably reflecting the introduction of Columbia River water to the Richland well field.

Relatively high-nitrate concentrations occur in wells trending from northwest to southeast through the study area (wells 699-S31-1, 3000-D-1, athletic complex, and 1100-D). In these wells, nitrates ranged from 12.5 to 165 p/m. In other wells, the concentrations ranged from <0.02 to 2.4 p/m. The source of the nitrates is unknown, but given the overall easterly flow of groundwater in the area (Newcomb et al. 1972), a single

Table B-2. Analytical Results for Sampled Wells in the 1100 Area - 3000 Area Study
(Units in parts per million [p/m]). (Sheet 1 of 2)

Well/Sample Constituent	3000-G 4903	3000-D 4907	3000-N 4907	699-S31-E13 4902	699-S32-E13A 4906	6-ORV 4898	699-S31-1 4606	6-ATH C 4899	1100-8 4901	3000-D-1 4900D	699-S36-13B 4905
TOX	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
TOC	4.206	5.762	3.748	1.38	1.608	BDL	1.001	2.499	1.278	2.786	9.736
F	<0.1	<0.1	<0.1	<0.1	0.28	1.3	0.94	0.34	0.1	0.16	0.27
Cl	0.85	0.8	1.1	5.5	4.5	2.3	4.8	50	26	6	4.2
NO ₃	0.45	0.35	1.5	2.4	21	<0.2	0.2	165	33	12.5	<0.2
SO ₄	20.5	9.1	10.0	4.4	20.5	<1	<1	5.9	40	16	13.8
PO ₄	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ba	0.11	0.1	0.15	0.2	0.47	<0.10	0.21	0.83	0.53	0.23	1.2
Cd	0.010	<0.0005	<0.0005	0.0072	0.0046	<0.0005	0.035	<0.0005	<0.0005	0.012	<0.0005
Mn	<0.1	<0.01	<0.01	1.0	0.16	<0.01	0.055	<0.01	<0.01	0.19	1.63
Na	3.5	3.7	4.1	20	20	42.8	43.7	72	31	17	25.4
K	1.1	0.95	1.82	7.0	9.8	9.6	7.8	13	8.5	5.1	13.2
Fe	<0.03	<0.03	<0.03	32.8	6.7	<0.3	1.67	<0.3	0.068	1.69	16.8
Pb	<0.005	<0.005	<0.005	0.017	0.008	<0.005	0.047	<0.005	<0.005	<0.005	<0.005
Al	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4.9
Cr	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

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Table B-2. Analytical Results for Sampled Wells in the 1100 Area - 3000 Area Study
(Units in parts per million [p/m]). (Sheet 2 of 2)

Well/Sample Constituent	3000-G 4903	3000-D 4907	3000-N 4907	699-S31-E13 4902	699-S32-E13A 4906	6-ORV 4898	699-S31-1 4606	6-ATH C 4899	1100-8 4901	3000-D-1 4900D	699-S36-13B 4905
Ag	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cu	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ni	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
V	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Hg	<0.0005	<0.0005	<0.0005	<0.001*	<0.0005	<0.0005	<0.001*	<0.0005	<0.0005	<0.0005	<0.0005
ABN	NA	NA	NA	BDL	NA	NA	**	NA	NA	NA	NA
VOA	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	***	BDL
HERB	NA	NA	NA	BDL	BDL	BDL***	BDL	BDL	BDL	BDL	BDL
PEST	NA	NA	NA	BDL	BDL	NA	BDL	NA	NA	BDL	BDL
Coliform	NEG	POS	NEG	NA	NA	NEG	NEG	NEG	NA	NA	NEG

ABN = Acid-base-neutral (semivolatile) organic compounds.

BDL = Below detection limit.

HERB = Herbicides.

NA = Not analyzed.

PEST = Pesticides.

TOC = Total organic carbon.

TOX = Total organic halogen.

VOA = Volatile organic compounds.

* Inadequate sample volume for normal detection limit.

** bis(2 ethylhexyl) phthalate (code B40) 22 p/b (no other ABNs detected).

*** Methylene chloride (code A93) 20 p/b (no other VOA detected).

**** Inadequate sample (detection limit = 0.0016 p/m).

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source is unlikely to account for the nitrates in all the wells with elevated concentrations.

Fluoride concentrations in all wells except ORV range from undetectable (<0.1 p/m) to 0.34 p/m. The ORV well had a fluoride concentration of 1.3 p/m. This value is probably explained by the fact that ORV is completed in confined aquifers of the Columbia River Basalt Group, which typically show an increase in fluoride with depth.

Sulphate concentrations vary throughout the study area. Concentrations range from the detection limit (<0.1 p/m) to a high of 40 p/m. No spatial pattern is evident.

Samples were analyzed for volatile organics (VOA), (semivolatile) ABNs, and/or herbicides and pesticides. The exact compounds analyzed were selected on a well-by-well basis depending on likely contaminants. Consequently, not all wells were analyzed for all organic constituents. The VOA and ABN are indicators of the presence of petrochemicals. Methylene chloride (20 p/b) was found in the groundwater from 3000-D-1 and bis(2-ethylhexyl) phthalate (22 p/b) was present in 699-S31-1. Petrochemicals, herbicides, and pesticides were not detected in the remaining samples. Total organic halogen (TOX) ranged from 0.0002 to 2.8 p/m. Total organic carbon ranged from 1 to 5.8 p/m.

Samples were analyzed for the following metals: barium, cadmium, chromium, silver, copper, mercury, sodium, nickel, manganese, vanadium, aluminum, iron, lead, and potassium. Of these, barium (9 of 10), cadmium (5 of 10), manganese (4 of 10), sodium (10 of 10), potassium (10 of 10), and iron (5 of 10) were present above detection limits. All other metals were below detection limits. Analyses for metals were done by ICP.

Relatively high barium concentrations were located in the same wells that exhibited relatively high nitrate (wells 699-S31-1, 3000-D-1, athletic complex, and 1100-D). For these wells, the barium values ranged from 0.47 to 0.83 p/m. In the remaining wells, barium ranged from undetectable (<0.1 p/m) to 0.23 p/m.

Samples from wells 699-S32-E13A, 3000-D1, and 3000-G had the highest cadmium levels. These wells are located in the northern half of the study area. Values range from undetectable (<0.005 p/m) to a high of 0.035 p/m.

Lead traces were found on the northern perimeter of the study area. Concentrations ranged from undetectable (<0.0005 p/m) to 0.047 p/m. Throughout most of the study area, lead concentrations were at levels too low to detect.

Potassium levels present in all the wells represent background levels for the Hanford Site unconfined aquifer (approximately 5 p/m, [Price et al. 1985]). For wells outside the 3000 group, potassium ranged from 5.1 to 13.2 p/m. Within the 3000 group, the range was 0.9 to 1.82 p/m.

Concentrations of sodium were also significantly lower in the 3000 group wells than in other wells. Values ranged from 3.5 to 4.1 p/m. Sodium in other parts of the area ranged from 17 to 72 p/m. As with several other constituents, this difference stems from the introduction of low TDS Columbia River water into the Richland well field, as well as higher sodium concentrations in the Yakima River compared to the Columbia River (Newcomb et al. 1972).

Along the northern perimeter of the study area, manganese was detected ranging from 0.055 to 1.0 p/m. It was below detection limits in most of the other samples.

Samples for coliform bacteria were drawn from six wells. Well 3000-D tested positive at 2.2 total coliform/100 mL, which is at the detection limit. All other samples tested negative.

Groundwater samples were also collected from seven wells in the vicinity of the 1100 Area during August 1988. The locations of the wells sampled are shown in Figure 2-1. The samples were collected as part of the Hanford site-wide groundwater monitoring project and were analyzed for volatile organic compounds by both PNL and U.S. Testing. Results above detection for volatile organics are presented in Table B-3. The gas chromatography (GC) technique employed by PNL typically yields detection limits 2 to 3 orders of magnitude lower than the GC/mass spectrometry (MS) technique used by U.S. Testing; thus, only two results above detection were reported by U.S. Testing.

Several hazardous constituents found on the lists in Appendix IX, 40 CFR Parts 264 and 270 (EPA 1980 and 1983, respectively) and in WAC-173-303-9905 (Ecology 1987) were detected (Table B-3). In all cases, the concentrations of the hazardous constituents detected were at least 20 times less than levels specified by applicable or relevant and appropriate requirements (see Section 7.0). Two trihalomethanes, chloroform (trichloromethane, CHCl_3) and bromodichloromethane, were detected in samples from several wells. Chloroform concentrations ranged from less than detection (0.05 p/b) in well 699-S29-E12 to 1.1 p/b in well 699-S41-13C. Bromodichloromethane was only found in concentrations greater than the detection limit (0.01 p/b) in wells 699-S36-E13A and 699-S41-13C. The maximum contaminant level (MCL) for total trihalomethanes in community water systems that serve a population of 10,000 or more individuals and that add a disinfectant to the water as part of the water treatment process is 100 p/b (40 CFR Part 141 [EPA 1986b]). The chlorinated hydrocarbons 1,1,1-trichloroethane (TCA) and trichlorethene (TCE) were also detected in several wells. The highest concentrations of TCA were measured in wells 699-S41-13C and 699-S36-E13A. The MCL for TCA is 200 p/b (40 CFR Parts 141 and 142). Concentrations of TCE less than 1 ppb were detected in most wells sampled. The MCL for TCE is 5 p/b (40 CFR Parts 141 and 142 [EPA 1986b and 1986c, respectively]). Perchloroethene was also detected in concentrations less than 1 p/b in all wells sampled. Perchloroethene is not listed as a hazardous constituent by EPA or Ecology. Carbon tetrachloride was below the detection limits (0.01 p/b) in all samples.

Table B-3. Volatile Organic Compounds Detected in 1100 Area Wells.

Well number	CHCl ₃ (p/b) ^a	1,1,1- Trichloroethane (p/b)	Trichloroethylene (p/b)	Bromodichloromethane (p/b)	Perchloroethylene (p/b)
699-S29-E12	<0.05	0.06	0.0	<0.01	0.03
699-S29-E12	<0.05	0.06	<0.01	<0.01	0.03
699-S32-E13A	0.37	0.35	0.16	<0.01	0.26
699-S32-E13A	0.37	0.35	0.16	<0.01	0.26
699-S32-E13B	0.50	0.39	0.18	<0.01	0.27
699-S31-1	0.38	0.04	0.02	<0.01	0.02
699-S31-1	0.39	<0.01	<0.01	<0.01	0.01
699-S41-13C	1.11	9.35	0.08	0.05	0.71
699-S41-13C	1.13	10.15	0.10	0.04	0.75
699-S41-13C ^b	<5	8.00	<5	<5	<5
699-S36-E13A	0.83	2.15	0.22	0.01	0.82
699-S36-E13A	0.81	2.19	0.23	0.01	0.84
699-S36-E13A ^b	<5	2	<5	<5	<5
699-S31-E13	0.40	0.40	0.15	<0.01	0.27
699-S31-E13	0.40	0.39	0.15	<0.01	0.27

NOTE = All analyses performed by Pacific Northwest Laboratory using gas chromatography except as noted.

^ap/b = parts per billion.

^bAnalysis performed by U.S. Testing using gas chromatography/mass spectrometry.

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5.0 REFERENCES

- Ecology, 1987, *Dangerous Waste Regulations*, Washington Administrative Code 173-303, Washington Department of Ecology, Olympia, Washington.
- EPA, 1980, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*, Title 40, Code of Federal Regulations, Part 264, as amended, U.S. Environmental Protection Agency, Washington, D.C.
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- EPA, 1986a, *Test Methods for Evaluating Solid Waste*, SW-846, 3rd Edition, U.S. Environmental Protection Agency, Washington, D.C.
- EPA, 1986b, *National Primary Drinking Water Regulations*, Title 40, Code of Federal Regulations, Part 141, as amended, U.S. Environmental Protection Agency, Washington, D.C.

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Newcomb, R. C., J. R. Strand, and F. J. Frank, 1972, *Geology and Groundwater Characteristics of the Hanford Reservation of the U.S. Atomic Energy Commission*, Washington, Professional Paper 717, U.S. Geological Survey, Washington, D.C.

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APPENDIX C
ENVIRONMENTAL INVESTIGATIONS AND
INSTRUCTIONS

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APPENDIX C

ENVIRONMENTAL INVESTIGATION INSTRUCTIONS (EII) IN PROCESS TO BE CLEARED FOR PUBLIC RELEASE

Number	Procedure title/topic	Anticipated issue date
EII 1.2	Preparation and revision of environmental investigation instructions	Completed
EII 1.4	Deviation from environmental investigation instructions	Completed
EII 1.5	Field logbooks	02/28/89
EII 1.6	Records management	02/28/89
EII 1.7	Indoctrination, training, and qualification	02/28/89
EII 2.1	Preparation of health and safety plans	Completed
EII 2.2	Dosimetry	Completed
EII 3.1	User calibration of measurement and test equipment (health/safety)	02/28/89
EII 5.1	Chain of custody	Completed
EII 5.2	Soil and sediment sampling	Completed
EII 5.3	Biotic sampling	03/31/89
EII 5.4	Field decontamination of drilling equipment	Completed
EII 5.5	Decontamination of equipment for RCRA/CERCLA sampling	Completed
EII 5.6	Gross gamma geophysical logging	02/28/89
EII 5.7	Hanford geotechnical library control (sample archiving)	03/28/89
EII 6.2	Groundwater monitoring well technical inspection	02/15/89
EII 6.3	Preparation of groundwater monitor well construction specifications	03/31/89
EII 9.1	Geologic logging	Completed
EII 10.1	Aquifer testing	02/28/89
EII 10.2	Groundwater-level monitoring	03/31/89
EII 10.3	Disposal of well construction development waters (purgewater disposal)	02/28/89

APPENDIX D

STATEMENT OF WORK FOR HAZARDOUS CHEMICAL ANALYTICAL SERVICES

1110253

STATEMENT OF WORK

I. HAZARDOUS CHEMICAL ANALYTICAL SERVICES

A. DEFINITIONS

In general, the terminology used throughout this Statement of Work is consistent with common usage. However, certain terminology used herein has the meaning below:

1. Audit sample - A quality control sample with a predetermined concentration or other measurable parameter used to evaluate the validity of an analytical process.
2. Blank Sample - A quality control sample (reagent or matrix) containing an insignificant quantity of the constituent of interest.
3. Business day - Any day, Monday through Friday that is not a legal holiday.
4. Business Hours - Any time between 7:30 a.m. and 5:00 p.m. on any business day.
5. Designated Service Client - An organization/entity designated by the Battelle contract Representative as authorized to order analytical tests.
6. EPA - U. S. Environmental Protection Agency.
7. Intermediate-level sample - A sample containing concentrations of chemicals and/or radionuclides >100 times the MDC.
8. Low-level sample - A sample containing concentrations of chemicals and/or radionuclides up to 100 times the MDC.
9. Minimum Detectable Concentration (MDC) - Required level of analytical detection.
10. Nonroutine Orders - Analytical tests ordered on a daily basis, as necessary.
11. RCRA - Resource Conservation and Recovery Act.
12. Routine Order - Analytical tests ordered on a daily basis in accordance with operational year sample collection schedules.
13. Sample Receipt - The point at which the processing instructions and the samples to be tested are both received at the Contractor's local receiving facility.

14. SDWA - Safe Drinking Water Act.
15. Spiked Sample - A quality control sample to which specific amounts of radionuclides or chemicals have been added.
16. Standard - Traceable to the National Bureau of Standards (NBS), the EPA or similar standardizing agencies.
17. Test User - An organizational element of Battelle or of a Designated Service Client.
18. Test User Identifier - The name "Battelle" or the name of a Designated Service Client followed by an alpha-numeric code.

B. SERVICES REQUIRED

This section specifies the processing of environmental, groundwater and other samples. Processing encompasses receipt, handling, and storage of samples, analytical testing, and reporting of results. Required tests include organic and inorganic chemical analyses, gross alpha and beta analyses, and general characteristics such as pH and conductivity.

The Contractor shall supply all facilities, equipment and materials necessary for the proper performance of the work unless otherwise specified in this contract.

C. SAMPLE CHARACTERISTICS

Samples to be processed are liquids, which include water and aqueous solutions, and solids, which include soil, sludge and sediments. Samples will be contained in various container types and sizes and may contain both chemical and radioactive materials.

D. PROCESSING REQUIREMENTS

1. Sample Scheduling and Collection

Routine orders may be transmitted on a daily basis by Battelle and its Designated Service Clients in accordance with operational year sample collection schedules provided to the Contractor at the start of each operational year. Nonroutine orders will be transmitted as necessary. The contractor shall provide a one point contact available at all times to receive nonroutine orders. All hazardous chemical samples will be collected by Battelle and its Designated Service Clients and delivered to the Contractor's local receiving facility. The equipment and supplies necessary for collection of such samples shall not be furnished by the Contractor.

All samples for which analytical tests are ordered will be clearly labeled and identified by Battelle and its Designated Service Clients. Each label will specify a unique sample identification, user identification and the analytical test ordered.

2. Sample Handling and Storage

The Contractor shall assure the integrity and security of all samples (initial and unused portions), sample extracts and other preparations, and analytical data and results through the rigorous application of chain-of-custody. Battelle and the Designated Service Clients will originate chain-of-custody forms. Chain-of-custody procedures shall be those specified in Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986).

The Contractor shall store samples so that samples can be retrieved in a timely manner.

The Contractor shall assure that any aliquots removed from a samples shall be representative of the entire sample. The Contractor shall store and preserve the integrity of the unused portions of samples, and any final analytical preparations with which measurements are made, for 20 business days following reporting of analytical results. The Contractor shall dispose of the residuals of all samples and all final analytical preparations.

3. Analytical Requirements

The Contractor shall perform, when ordered, analytical tests for any single constituent or any group of constituents specified in this Section D.3; provided, however, that the Contractor shall be excused from attaining any MDC specified herein when, due to the presence of interfering species in a sample to be processed, such MDC cannot be attained utilizing the procedures provided for in the Contractor's approved procedures manual.

Reasonable efforts shall be made by the Contractor to assist Battelle and its Designated Service Clients in minimizing the volume of sample and number of sample containers necessary to achieve the required analytical tests.

The Contractor shall perform data rechecks of previously reported results as if ordered by the Battelle Technical Administrator or a Designated Service Client. Data rechecks shall consist of a review of calculations, aliquot size, yield, and other data pertinent to the reported analytical result. The Contractor shall also review the results of quality control samples as well as the results of other samples processed in the same batch. The quality control sample results and the results of the Contractor's data recheck evaluations shall be delivered in writing to the Battelle Technical Administrator for Battelle orders or the Test User for other orders.

The Contractor shall perform analytical tests on the preserved unused portions of samples, if ordered by the Battelle Technical Administrator or Designated Service Client. The analytical specifications listed in Section D shall apply.

The Contractor shall perform reanalysis of the preserved final analytical preparations from samples previously analyzed, if ordered by the Battelle Technical Administrator or a Designated Service Client. Reanalysis shall include repetition of, as appropriate to each analytical test, the final steps in the analytical procedure. The Contractor shall report the results of reanalyses in writing in accordance with the specifications of Section E.1.

All analytical test and processing procedures (including chain-of-custody) shall be compiled in a procedures manual that is maintained current. All such procedures shall undergo internal Contractor review and approval prior to submittal to the Battelle Contract Representative for written approval prior to implementation. All such procedure and equipment changes shall be delivered to the Battelle Contract Representative for written approval prior to implementation.

The following analytical tests for the constituents listed shall be performed by Induction Coupled Argon Plasma Spectrometry Method 6010 of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986).

CONSTITUENT	MDC		SAMPLE SIZE	
	LIQUIDS	SOLIDS	LIQUIDS	SOLIDS
ALUMINUM	150 µg/l	15 µg/g		
ANTIMONY	100 µg/l	10 µg/g		
BARIUM	6 µg/l	0.6 µg/g		
BERYLLIUM	3 µg/l	0.3 µg/g		
BORON	10 µg/l	1 µg/g		
CADMIUM	5 µg/l	0.5 µg/g		
CALCIUM	50 µg/l	5 µg/g		
CHROMIUM	10 µg/l	1 µg/g		
COBALT	20 µg/l	2 µg/g		
COPPER	10 µg/l	1 µg/g		
IRON	30 µg/l	5 µg/g		
LITHIUM	10 µg/l	10 µg/g	1 l	10 g
MAGNESIUM	50 µg/l	5 µg/g		
MANGANESE	5 µg/l	0.5 µg/g		
MOLYBDENUM	40 µg/l	4 µg/g		
NICKEL	10 µg/l	1 µg/g		
POTASSIUM	100 µg/l	10 µg/g		
SILICON	50 µg/l	5 µg/g		
SILVER	10 µg/l	1 µg/g		
TITANIUM	60 µg/l	6 µg/g		
SODIUM	200 µg/l	10 µg/g		
STRONTIUM	10 µg/l	1 µg/g		
TIN	30 µg/l	3 µg/g		
VANADIUM	5 µg/l	0.5 µg/g		
ZINC	5 µg/l	0.5 µg/g		
ZIRCONIUM	50 µg/l	5 µg/g		

The following analytical tests for the constituents listed shall be performed by atomic absorption in accordance with the methods of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986), as indicated:

Constituent	SW-846 Test Method
ARSENIC	7060 or 7061
LEAD	7421
MERCURY	7470
SELENIUM	7740 or 7741
THALLIUM	7841

Minimum detectable concentrations and sample sizes are:

Constituent	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
ARSENIC	5 $\mu\text{g/l}$	0.5 $\mu\text{g/g}$	1 l	10 g
LEAD	5 $\mu\text{g/l}$	0.5 $\mu\text{g/g}$	1 l	10 g
MERCURY	0.1 $\mu\text{g/l}$	0.2 $\mu\text{g/g}$	500 ml	10 g
SELENIUM	5 $\mu\text{g/l}$	0.5 $\mu\text{g/g}$	1 l	10 g
THALLIUM	5 $\mu\text{g/l}$	1.0 $\mu\text{g/g}$	1 l	10 g

The following analytical tests for the constituents listed shall be performed by ion chromatography in accordance with method 300.0 of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986) or method D4327-84 of the Annual Book of ASTM Standards, (Volume 11.01, 1986).

Constituent	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
NITRATE	2500 $\mu\text{g/l}$		125 ml	
BROMIDE	1000 $\mu\text{g/l}$		125 ml	
NITRITE	1000 $\mu\text{g/l}$			
BROMIDE	1000 $\mu\text{g/l}$	1 $\mu\text{g/g}$		
CHLORIDE	500 $\mu\text{g/l}$	1 $\mu\text{g/g}$		
FLUORIDE	500 $\mu\text{g/l}$	1 $\mu\text{g/g}$	125 ml	50 g
NITRATE	500 $\mu\text{g/l}$	1 $\mu\text{g/g}$		
NITRITE	1000 $\mu\text{g/l}$	1 $\mu\text{g/g}$		
PHOSPHATE	1000 $\mu\text{g/l}$	2 $\mu\text{g/g}$		
SULFATE	500 $\mu\text{g/l}$	1 $\mu\text{g/g}$		

Analytical tests for perchlorate and oxalate and ferrocyanide shall be performed by ion exclusion chromatography or other method. Either method shall be clearly documented and the adequacy of either method shall be verified by the Contractor through the performance of quality control analyses. The minimum detectable concentrations and sample sizes are:

Constituent	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
FERROCYANIDE	50 $\mu\text{g/l}$	0.5 $\mu\text{g/g}$	1 l	50 g
PERCHLORATE	500 $\mu\text{g/l}$	1 $\mu\text{g/g}$	125 ml	50 g
OXALATE	500 $\mu\text{g/l}$	1 $\mu\text{g/g}$		

Analytical tests for fluoride shall be performed by ion selective electrode in accordance with ASTM Method D 11798 of the Annual Book of ASTM Standards, (Volume 11.01, 1986). The method of standard additions shall be used. The minimum detectable concentration and sample sizes are:

<u>Constituent</u>	<u>MDC</u>		<u>SAMPLE SIZE</u>	
	<u>Liquid</u>	<u>Solid</u>	<u>Liquid</u>	<u>Solid</u>
FLUORIDE	50 $\mu\text{g/l}$	1 $\mu\text{g/g}$	250 ml	50 g

The following analytical tests for the constituents listed shall be performed in accordance with the methods of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986) or the Annual Book of ASTM Standards, (Volume 11.01, 1986), as indicated:

<u>Constituent</u>	<u>Test Method</u>
CHROMIUM (VI)	SW-846 Method 7196 or 7197
SULFIDE	SW-846 Method 9030
AMMONIUM ION	ASTM Method D 1426-D or D 1426-C
CYANIDE	SW-846 Method 9010

The minimum detectable concentrations and sample sizes are:

<u>Constituent</u>	<u>MDC</u>		<u>SAMPLE SIZE</u>	
	<u>Liquid</u>	<u>Solid</u>	<u>Liquid</u>	<u>Solid</u>
CHROMIUM (VI)	50 $\mu\text{g/l}$	1 $\mu\text{g/g}$	250 ml	50 g
SULFIDE	1000 $\mu\text{g/l}$	10 $\mu\text{g/g}$	1 l	50 g
AMMONIUM ION	50 $\mu\text{g/l}$	0.5 $\mu\text{g/g}$	350 ml	50 g
CYANIDE	10 $\mu\text{g/l}$	0.5 $\mu\text{g/g}$	2 l	50 g

The following analytical tests for water quality shall be performed in accordance with the methods of the Annual Book of ASTM Standards, (Volume 11.01, 1986) or Standard Methods for the Examination of Water and Wastewater, Sixteenth Edition (1985), as indicated:

<u>Analytical Test</u>	<u>Test Method</u>
ALKALINITY	ASTM Method D 1067 A
CONDUCTIVITY	ASTM Method D 1125 A
pH	ASTM Method D 1293
TOTAL DISSOLVED SOLIDS (TDS)	ASTM Method D 1888A or Standard Method #2098

The minimum detectable concentrations and sample sizes are:

<u>Constituent</u>	<u>MDC</u> <u>Liquid</u>	<u>SAMPLE SIZE</u> <u>Liquid</u>
ALKALINITY	20 mg/l	250 ml
CONDUCTIVITY	NA	250 ml
pH	NA	250 ml
TOTAL DISSOLVED SOLIDS (TDS)	5 mg/l	100 ml

The following analytical tests for radioactivity shall be performed in accordance with the methods of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986), as indicated:

<u>Analytical Test</u>	<u>SW-846 Test Method</u>
RADIUM ()	9315
GROSS ALPHA	9310
GROSS BETA	9310

The minimum detectable concentrations and sample sizes are:

Constituent	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
RADIUM ()	1 pCi/l	1 pCi/g	1 l	50 g
GROSS ALPHA	4 pCi/l	6 pCi/g	1 l	5 g
GROSS BETA	8 pCi/l	3 pCi/g	1 l	5 g

The following analytical tests for the constituents listed shall be performed by method 8080 of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986).

Constituent	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
ENDRIN	0.1 µg/l	0.01 µg/g		
LINDANE (and isomers)	0.1 µg/l	0.01 µg/g	2 l	50 g
METHOXYCHLOR	3 µg/l	1 µg/g		
TOXAPHENE	1 µg/l	1 µg/g		
ENDRIN	0.1 µg/l	0.01 µg/g		
LINDANE (and isomers)	0.1 µg/l	0.01 µg/g		
METHOXYCHLOR	3 µg/l	1 µg/g		
TOXAPHENE	1 µg/l	1 µg/g		
ALDRIN	0.1 µg/l	0.01 µg/g		
CHLORDANE	1 µg/l	1 µg/g		
4,4'-DDD	0.1 µg/l	0.01 µg/g		
4,4'-DDE	0.1 µg/l	0.01 µg/g	2 l	50
4,4'-DDT	0.1 µg/l	0.01 µg/g		
ENDOSULFAN I	0.1 µg/l	0.01 µg/g		
ENDOSULFAN II	0.1 µg/l	0.01 µg/g		
ENDOSULFAN SULFATE	0.5 µg/l	0.05 µg/g		
HEPTACHLOR	0.1 µg/l	0.01 µg/g		
HEPTACHLOR EPOXIDE	0.1 µg/l	0.01 µg/g		
KEPONE	1 µg/l	1 µg/g		
DIELDRIN	0.1 µg/l	0.01 µg/g		
CHLOROBENZILATE	300 µg/l	0.3 µg/g		
POLYCHLORINATED BIPHENYLS	1 µg/l	1 µg/g	2 l	50 g

Analytical tests for chlorinated herbicides shall be performed by Method 8150 of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986).

The minimum detectable concentrations and sample sizes are:

Constituent	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
2,4-D	2 µg/l	1 µg/g	2 l	200 g
2,4,5-TP Silvex	2 µg/l	1 µg/g		
2,4,5-T	2 µg/l	1 µg/g		

Analytical tests for phosphorus pesticides shall be performed by Method 8140 of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986).

The minimum detectable concentrations and sample sizes are:

Constituent	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
CARBOPHENOTHION	2 µg/l	1 µg/g	2 l	50 g
DIMETHOATE	2 µg/l	0.2 µg/g		
DISULFOTON	2 µg/l	1 µg/g		
METHYL PARATHION	2 µg/l	1 µg/g		
PARATHION	2 µg/l	1 µg/g		
PHORATE	2 µg/l	1 µg/g		
TETRAETHYLPYROPHOSPHATE	2 µg/l	1 µg/g		

Analytical tests for halogenated volatile organics shall be performed by gas chromatography in accordance with Method 8010 of Tests for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986).

Constituent	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
CARBON TETRACHLORIDE	1 µg/l	0.001 µg/g	40 ml	10 g
CHLOROFORM	5 µg/l	0.005 µg/g		
p-DICHLOROBENZENE	2 µg/l	0.002 µg/g		
1,1 DICHLOROETHANE	1 µg/l	0.001 µg/g		
1,2 DICHLOROETHANE	0.5 µg/l	0.0005 µg/g		
trans-1,2 DICHLOROETHYLENE	1 µg/l	0.001 µg/g		
METHYLENE CHLORIDE	5 µg/l	0.005 µg/g		
TETRACHLOROETHYLENE	0.5 µg/l	0.0005 µg/g		
1,1,1-TRICHLOROETHANE	0.2 µg/l	0.0002 µg/g		
1,1,2-TRICHLOROETHANE	0.2 µg/l	0.0002 µg/g		
TRICHLOROETHYLENE	1 µg/l	0.001 µg/g		
VINYL CHLORIDE	2 µg/l	0.002 µg/g		

The following analytical tests for the constituents listed shall be performed by Method 8240 of Tests for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986). Introduction of liquid samples shall use SW-846 Method 5030, Purge-and-Trap. The instrument shall be calibrated for constituents listed in upper case letters. Analytical tests that include targeted constituents do not require additional calibration. Identification and quantification of each additional targeted constituent shall be accomplished by forward search using the EPA/NIH Mass Spectral Data Base. Analytical tests that include non-targeted constituents, i.e., any other compound in the EPA/NIH Mass Spectral Data Base, do not require additional calibration. Identification and quantification of any observed unknown peak not associated with the constituents specifically listed in this Statement of Work shall be accomplished by forward search using the EPA/NIH Mass Spectral Data Base.

The minimum detectable concentrations and sample sizes are:

CONSTITUENT	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
BENZENE	5 µg/l	0.005 µg/g		
CARBON TETRACHLORIDE	5 µg/l	0.005 µg/g		
CHLOROFORM	5 µg/l	0.005 µg/g		
p-DICHLOROBENZENE	5 µg/l	0.005 µg/g		
1,1 DICHLOROETHANE	5 µg/l	0.005 µg/g		
1,2 DICHLOROETHANE	5 µg/l	0.5 µg/g		
trans-1,2 DICHLOROETHYLENE	5 µg/l	0.005 µg/g		
METHYL ISOBUTYL KETONE	10 µg/l	0.01 µg/g		
METHYLETHYL KETONE	10 µg/l	0.01 µg/g		
METHYLENE CHLORIDE	5 µg/l	0.005 µg/g		
TETRACHLOROETHYLENE	5 µg/l	0.005 µg/g		
TOLUENE	5 µg/l	0.005 µg/g	40 ml	10 g
1,1,1-TRICHLOROETHANE	5 µg/l	0.005 µg/g		
1,1,2-TRICHLOROETHANE	5 µg/l	0.005 µg/g		
TRICHLOROETHYLENE	5 µg/l	0.005 µg/g		
VINYL CHLORIDE	10 µg/l	0.01 µg/g		
XYLENE	5 µg/l	0.005 µg/g		
BENZENE	5 µg/l	0.005 µg/g		
CARBON TETRACHLORIDE	5 µg/l	0.005 µg/g		
CHLOROFORM	5 µg/l	0.005 µg/g		
p-DICHLOROBENZENE	5 µg/l	0.005 µg/g		
1,1 DICHLOROETHANE	5 µg/l	0.005 µg/g		
1,2 DICHLOROETHANE	5 µg/l	0.5 µg/g		
trans-1,2 DICHLOROETHYLENE	5 µg/l	0.005 µg/g		
METHYL ISOBUTYL KETONE	10 µg/l	0.01 µg/g		
METHYLETHYL KETONE	10 µg/l	0.01 µg/g		
METHYLENE CHLORIDE	5 µg/l	0.005 µg/g		
TETRACHLOROETHYLENE	5 µg/l	0.005 µg/g		
TOLUENE	5 µg/l	0.005 µg/g	40 ml	10 g
1,1,1-TRICHLOROETHANE	5 µg/l	0.005 µg/g		
1,1,2-TRICHLOROETHANE	5 µg/l	0.005 µg/g		
TRICHLOROETHYLENE	5 µg/l	0.005 µg/g		
VINYL CHLORIDE	10 µg/l	0.01 µg/g		
XYLENE	5 µg/l	0.005 µg/g		
Additional Targeted Constituents (see Table 1)				

CONSTITUENT	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
BENZENE	5 µg/l	0.005 µg/g		
CARBON TETRACHLORIDE	5 µg/l	0.005 µg/g		
CHLOROFORM	5 µg/l	0.005 µg/g		
p-DICHLOROBENZENE	5 µg/l	0.005 µg/g		
1,1 DICHLOROETHANE	5 µg/l	0.005 µg/g		
1,2 DICHLOROETHANE	5 µg/l	0.5 µg/g		
trans-1,2 DICHLOROETHYLENE	5 µg/l	0.005 µg/g		
METHYL ISOBUTYL KETONE	10 µg/l	0.01 µg/g		
METHYLETHYL KETONE	10 µg/l	0.01 µg/g		
METHYLENE CHLORIDE	5 µg/l	0.005 µg/g		
TETRACHLOROETHYLENE	5 µg/l	0.005 µg/g		
TOLUENE	5 µg/l	0.005 µg/g	40 ml	10 g
1,1,1-TRICHLOROETHANE	5 µg/l	0.005 µg/g		
1,1,2-TRICHLOROETHANE	5 µg/l	0.005 µg/g		
TRICHLOROETHYLENE	5 µg/l	0.005 µg/g		
VINYL CHLORIDE	10 µg/l	0.01 µg/g		
XYLENE	5 µg/l	0.005 µg/g		
Additional Targeted Constituents				
(see Table 1)				
Non-Targeted Constituents				
(EPA/NIH Data Base)				

Table 1

Additional Targeted Constituents for
Method 8240 Analytical Tests

CONSTITUENT	MDC	
	Liquid	Solid
acetonitrile	10 µg/l	0.01 µg/g
acrolein	10 µg/l	0.01 µg/g
acrylonitrile	10 µg/l	0.01 µg/g
allyl chloride	100 µg/l	0.1 µg/g
bis(chloromethyl) ether	5 µg/l	0.005 µg/g
bromoacetone	5 µg/l	0.005 µg/g
bromodichloromethane	5 µg/l	0.005 µg/g
bromoform	5 µg/l	0.005 µg/g
carbon disulfide	10 µg/l	0.01 µg/g
chlorobenzene	5 µg/l	0.005 µg/g
chloroethane	10 µg/l	0.01 µg/g
2-chloroethyl vinyl ether	5 µg/l	0.005 µg/g
chloromethyl methyl ether	10 µg/l	0.01 µg/g
crotonaldehyde	10 µg/l	0.01 µg/g
dibromochloromethane	5 µg/l	0.005 µg/g
1,2-dibromo-3-chloropropane	10 µg/l	0.01 µg/g
1,2-dibromoethane	10 µg/l	0.01 µg/g
dibromomethane	10 µg/l	0.01 µg/g
1,4-dichloro-2-butene	10 µg/l	0.01 µg/g
dichlorodifluoromethane	10 µg/l	0.01 µg/g
1,2-dichloropropane	5 µg/l	0.005 µg/g
1,3-dichloropropene	5 µg/l	0.005 µg/g
1,2-dimethylhydrazine	10 µg/l	0.01 µg/g
1,1-dimethylhydrazine	10 µg/l	0.01 µg/g
1,4-dioxane	500 µg/l	0.5 µg/g
ethyl benzene	5 µg/l	0.005 µg/g
ethylene oxide	10 µg/l	0.01 µg/g
ethyl methacrylate	10 µg/l	0.01 µg/g
formaldehyde	500 µg/l	0.5 µg/g
2-hexanone	50 µg/l	0.05 µg/g
iodomethane	10 µg/l	0.01 µg/g
methacrylonitrile	10 µg/l	0.01 µg/g
methanethiol	10 µg/l	0.01 µg/g
methyl chloride	10 µg/l	0.01 µg/g
methyl bromide	10 µg/l	0.01 µg/g
methylene chloride	5 µg/l	0.005 µg/g
N,N-diethylhydrazine	10 µg/l	0.01 µg/g
pentachloroethane	10 µg/l	0.01 µg/g
propionitrile	5 µg/l	0.005 µg/g
pyridine	500 µg/l	0.5 µg/g
1,1,1,2-tetrachlorethane	10 µg/l	0.01 µg/g
1,1,2,2-tetrachlorethane	5 µg/l	0.005 µg/g

Table 1 (continued)

Additional Targeted Constituents for
Method 8240 Analytical Tests

CONSTITUENT	MDC	
	Liquid	Solid
trans-1,2-dichloroethene	5 µg/l	0.005 µg/g
trichloromethanethiol	10 µg/l	0.01 µg/g
trichloromonofluoromethane	10 µg/l	0.01 µg/g
1,2,3-trichloropropane	10 µg/l	0.01 µg/g
styrene	5 µg/l	0.005 µg/g
vinyl acetate	5 µg/l	0.005 µg/g

The following analytical tests for the constituents listed shall be performed by Method 8270 of Tests for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986). Constituents are to be extracted from liquid samples by SW-846 Method 3510. Constituents are to be extracted from solid samples by SW-846 Method 3540 or 3550. The instrument shall be calibrated for constituents listed in upper case letters. Analytical tests that include targeted constituents do not require additional calibration. Identification and quantification of each additional targeted constituent shall be accomplished by forward search using the EPA/NIH Mass Spectral Data Base. Analytical tests that include non-targeted constituents, i.e., any other compound in the EPA/NIH Mass Spectral Data Base, do not require additional calibration. Identification and quantification of any observed unknown peak not associated with the constituents specifically listed in this Statement of Work shall be accomplished by forward search using the EPA/NIH Mass Spectral Data Base.

When Phenol is requested as a single constituent analytical test, the analytical test shall be performed by SW-846 Method 8040.

The minimum detectable concentrations and sample sizes are:

CONSTITUENT	MDC		SAMPLE SIZE	
	Liquid	Solid	Liquid	Solid
PHENOL	10 µg/l	1 µg/l	2 l	50 g
CHLORINATED BENZENES	10 µg/l	1 µg/g		
HEXACHLOROPHENE	10 µg/l	1 µg/g	2 l	50 g
KEROSENE	10 mg/l	1000 µg/g		
NAPHTHALENE	10 µg/l	1 µg/g		
PHENOL	10 µg/l	1 µg/l		
TRIBUTYL PHOSPHATE	10 µg/l	1 µg/g		
	MDC		SAMPLE SIZE	

CONSTITUENT	Liquid	Solid	Liquid	Solid
CHLORINATED BENZENES	10 µg/l	1 µg/g		
CRESOL	10 µg/l	1 µg/g		
HEXACHLOROPHENE	10 µg/l	1 µg/g		
KEROSENE	10 mg/l	1000 µg/g		
MALAIC HYDRAZIDE	500 µg/l	50 µg/g		
NAPTHALENE	10 µg/l	1 µg/g	2 l	50 g
NICOTINIC ACID	100 µg/l	10 µg/g		
PENTACHLOROPHENOL	50 µg/l	5 µg/g		
PHENOL	10 µg/l	1 µg/g		
STRYCHNINE	50 µg/l	5 µg/g		
TRIBUTYL PHOSPHATE	10 µg/l	1 µg/g		
Additional Targeted Constituents (See Table 2)	10 µg/l	1 µg/g		
CHLORINATED BENZENES	10 µg/l	1 µg/g		
CRESOL	10 µg/l	1 µg/g		
HEXACHLOROPHENE	10 µg/l	1 µg/g		
KEROSENE	10 mg/l	1000 µg/g		
MALEIC HYDRAZIDE	500 µg/l	50 µg/g		
NAPTHALENE	10 µg/l	1 µg/g	2 l	50 g
NICOTINIC ACID	100 µg/l	10 µg/g		
PENTACHLOROPHENOL	50 µg/l	5 µg/g		
PHENOL	10 µg/l	1 µg/g		
STRYCHNINE	50 µg/l	5 µg/g		
TRIBUTYL PHOSPHATE	10 µg/l	1 µg/g		
Additional Targeted Constituents (See Table 2)	10 µg/l	1 µg/g		
Non-targeted Constituents (EPA/NIH Data Base)				

TABLE 2

Additional Targeted Constituents for
Method 8270 Analytical Tests

acenaphthene
acenaphthalene
acetone
acetophenone
2-acetylaminofluorene
amitrole
4-aminobiphenyl
5-(aminomethyl)-3-isoxazolol
aniline
anthracene
aramite
auramine
bena[a]anthracene
benezenethiol
benz[c]acridine
benzene, dichloromethyl
benzidine
benzo[a]pyrene
benzo[b]fluoranthene
benzo[j]fluoranthene
benzo[k]fluoranthene
benzo[ghi]perylene
benzyl alcohol
benzyl chloride
bis(2-chloroethoxy) methane
bis(2-chloroethyl) ether
bis(2-chloro-1-methylethyl) ether
bis(2-chloroisopropyl) ether
bis(2-ethylhexyl) phthalate
4-bromophenyl phenyl ether
butyl benzyl phthalate
2-sec-butyl-4,6-dinitrophenol
chlornaphazine
chloroalkyl ethers
1-chloro-2,3-epoxypropane
2-chloronaphthalene
2-chlorophenol
chrysene
2-cyclohexyl-4,6-dinitrophenol
diallate
dibenzofuran
di-n-butyl phthalate
dibenz[a,h]acridine
dibenz[a,h]anthracene
dibenz[a,j]acridine

TABLE 2 (continued)

Additional Targeted Constituents for
Method 8270 Analytical Tests

7H-dibenzo[c,g]carbazole
dibenzo[a,e]pyrene
dibenzo[a,h]pyrene
dibenzo[a,i]pyrene
1,4-dichlorobenzene
1,2-dichlorobenzene
1,3-dichlorobenzene
3,3'-dichlorobenzidine
2,6-dichlorophenol
2,4-dichlorophenol
diethyl phthalate
O,O-diethyl O-2-pyrazinyl phosphorothionate
dihydrosafrole
alpha,alpha-dimethylphenethylamine
3,3'-dimethoxybenzidine
7,12-dimethylbenz[a]anthracene
3,3'-dimethylbenzidine
3,3'-dimethoxybenzidine
dimethyl phthalate
7,12-dimethylbenz[a]anthracene
m-dinitrobenzene
4,6-dinitro-o-cresol
2,4-dinitrophenol
2,6-dinitrotoluene
2,4-dinitrotoluene
dinoseb
di-n-octyl phthalate
diphenylamine
1,2-diphenylhydrazine
di-n-propylnitrosamine
ethyl methanesulfonate
ethyleneimine
fluoranthene
fluorene
hexachlorobenzene
hexachlorobutadiene
hexachlorocyclopentadiene
hexachloroethane
hexachloropropene
indeno(1,2,3-cd)pyrene
isodrin
isophorone
isosafrole
malononitrile
melphalan
methapyrilene

TABLE 2 (continued)

Additional Targeted Constituents for
Method 8270 Analytical Tests

2-methol-2-(methylthio)propionaldehyde-o-
(methylcarbonyl)oxime
metholonyl
2-methylaziridine
3-methylcholanthrene
4,4'-methylenebis(2-chloroaniline)
2-methylaconitrile
methyl methacrylate
methyl methanesulfonate
2-methylnaphthalene
methylthiouracil
1,4-naphthoquinone
1-naphthylamine
2-naphthylamine
o-nitroaniline
p-nitroaniline
m-nitroaniline
nitrobenzene
o-nitrophenol
p-nitrophenol
4-nitroquinoline 1-oxide
N-nitroso-N-methylurethane
N-nitrosodi-n-butylamine
N-nitrosodiethanolamine
N-nitrosodiethylamine
N-nitrosodimethylamine
N-nitrosodiphenylamine
N-nitrosomethylethylamine
N-nitrosomethylvinylamine
N-nitrosomorpholine
N-nitrosornicotine
N-nitrosopiperidine
nitrosopyrrolidine
5-nitro-o-toluidine
o-toluidine
p-benzoquinone
p-chloro-m-cresol
p-chloroaniline
p-dimethylaminoazobenzene
pentachlorobenzene
pentachloronitrobenzene
phentacetin
phenanthrene
p-phenylenediamine
phthalic acid esters
2-picoline

TABLE 2 (continued)

Additional Targeted Constituents for
Method 8270 Analytical Tests

pronamide
pyrene
reserpine
resorcinol
safrole
1,2,4,5-tetrachlorobenzene
2,3,4,6-tetrachlorophenol
thiofanox
thiuram
toluenediamine
1,2,4-trichlorobenzene
2,4,6-trichlorophenol
2,4,5-trichlorophenol
0,0,0-triethyl phosphorothioate
sym-trinitrobenzene
tris(2,3-dibromopropyl) phosphate
warfarin

9-11:70-027d

The following analytical tests for the constituents listed shall be performed by direct aqueous injection gas chromatography. The method shall be clearly documented and the adequacy of the method shall be verified by the Contractor through the performance of quality control analyses.

The minimum detectable concentrations and sample sizes are:

<u>Constituent</u>	<u>MDC</u>		<u>SAMPLE SIZE</u>	
	<u>Liquid</u>	<u>Solid</u>	<u>Liquid</u>	<u>Solid</u>
ETHYLENE GLYCOL	10 mg/l	10 µg/g	40 ml	50 g
ACRYLAMIDE	10 mg/l	10 µg/g		
ALLYL ALCOHOL	2.5 mg/l	10 µg/g		
CHLOROACETALDEHYDE	16 mg/l	10 µg/g		
3-CHLOROPROPIONITRILE	4 mg/l	10 µg/g		
ETHYL CARBAMATE	5 mg/l	10 µg/g	40 ml	50 g
ETHYL CYANIDE	2 mg/l	10 µg/g		
ETHYLENE GLYCOL	10 MG/L	10 µg/g		
ISOBUTYL ALCOHOL	1 mg/l	10 µg/g		
PARALDEHYDE	2 mg/l	10 µg/g		
N-PROPYLAMINE	10 mg/l	10 µg/g		
2-PROPYB-1-OL	8 mg/l	10 µg/g		

The following analytical tests for the constituents listed shall be performed by a method or methods that are clearly documented by the Contractor. The adequacy of the method or methods shall be verified by the Contractor through the performance of quality control analyses.

The minimum detectable concentrations and sample sizes are:

<u>Constituent</u>	<u>MDC</u>		<u>SAMPLE SIZE</u>	
	<u>Liquid</u>	<u>Solid</u>	<u>Liquid</u>	<u>Solid</u>
THIOUREA	200 µg/l	2 µg/g	40 ml	50 g
THIOUREA	200 µg/l	2 µg/g		
1-ACETYL-2-THIOUREA	200 µg/l	2 µg/g		
1-(O-CHLOROPNYNEL) THIOUREA	200 µg/l	2 µg/g		
DIETHYLSTILBESTEROL	200 µg/l	2 µg/g		
ETHYLENETHIOUREA	200 µg/l	2 µg/g	40 ml	50 g
1-NAPHTHYL-2-THIOUREA	200 µg/l	2 µg/g		
N-PHENYLTHIOUREA	500 µg/l	5 µg/g		

Analytical tests for dioxins shall be performed by Method 8280 of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986). The minimum detectable concentrations and sample sizes are:

<u>Constituent</u>	<u>MDC</u>		<u>SAMPLE SIZE</u>	
	<u>Liquid</u>	<u>Solid</u>	<u>Liquid</u>	<u>Solid</u>
PCDD's	0.01 µg/l	0.00001 µg/g	1 l	50 g
PCDF's	0.01 µg/l	0.00001 µg/g		
2,3,7,8 TCDD	0.01 µg/l	0.00001 µg/g		

The following analytical tests shall be performed in accordance with the methods of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986) or the Annual Book of ASTM Standards, (Volumes 11.01 and 11.02, 1986), as indicated:

<u>Analytical Test</u>	<u>Test Method</u>
HYDRAZINE	ASTM D1385 (Volume 11.01)
TOTAL ORGANIC HALIDES (TOX)	SW-846 Method 9020
TOTAL ORGANIC CARBON (TOC)	SW-846 Method 9060
TOTAL CARBON (TC)	ASTM D 2579 A or B (Volume 11.02)

The minimum detectable concentrations and sample sizes are:

<u>Constituent</u>	<u>MDC</u>		<u>SAMPLE SIZE</u>	
	<u>Liquid</u>	<u>Solid</u>	<u>Liquid</u>	<u>Solid</u>
HYDRAZINE	30 µg/l		250 ml	
TOTAL ORGANIC HALIDES	10 µg/l		250 ml	
TOTAL ORGANIC CARBON	2 mg/l		250 ml	
TOTAL CARBON	2 mg/l		250 ml	

Analytical tests for coliform bacteria shall be performed by Method 9131 of Test Methods for Evaluating Solid Wastes, USEPA, SW-846, Third Edition (1986) with a minimum Maximum Probable Number (MPN) of 2.2. Samples exhibiting the maximum MPN for a five tube test on 10 ml aliquots shall be rerun by the serial dilution method to determine the maximum coliform count. Sample size shall be 100 ml.

E. REPORTS AND COMMUNICATIONS

Communications of analytical results by the Contractor shall be made only in accordance with procedures specified in this Statement of Work. In no case shall reports, results, or data be released to a third party without the prior written permission of the Battelle Contract Representative.

The Contractor shall conduct routine monthly coordination/review meetings with Battelle and its Designated Service Clients. These meetings shall take place on or near the Hanford site.

The Contractor shall maintain records of data and other technical information generated in the performance of the services described in this contract. The Contractor shall retain such records for each operational year for the full term of this contract together with a records inventory which identifies the total number of containers (of standard size) or total volume of records (cubic feet). The Contractor shall update the inventory semiannually and make it available to Battelle upon request. Records disposition at completion of contract performance shall be as directed by the Battelle Contract Representative.

1. Reporting Results of Analyses

The following information shall be provided for each test result reported:

- Designed Service Client or Battelle identifier code
- Code for insert/modify
- Well code (if applicable)
- Depth code (if applicable)
- Duplicate number (if applicable)
- Constituent code (name and number)
- Group constituent code (if applicable)
- Sample collection date
- Sample collection time
- Extraction date (if applicable)
- Sample identification number (Contractor supplied)
- Analysis value
- Analytical uncertainty (error)
- Less than detection limit flag (if applicable)
- Sample size
- Analysis date
- Report date
- Number of dilutions
- Confirmation analysis (if applicable)
- Comments

The Contractor shall deliver reports on a weekly basis to the Battelle Technical Administrator for Battelle orders or the Test Users for other orders, in accordance with the following specifications for normal, priority and rapid processing.

Reports for all normally processed analytical tests of liquid samples shall be delivered within 25 business days from sample receipt. Reports for all normally processed analytical tests of solid samples shall be delivered within 35 business days of sample receipt.

Reports for all priority processed analytical tests shall be delivered orally within 10 business days of sample receipt and confirmed in writing with the next scheduled report.

Reports for all rapid processed analytical tests shall be delivered orally within 24 hours of sample receipt or upon completion of the ordered analysis, consistent with analytical tests procedure limitations, and confirmed in writing with the next scheduled report.

Reports shall consist of electronic data processing magnetic tape compatible with the Battelle VAX system and a printed report, or a printed report. The Battelle Contract Representative will specify the medium to be used in reporting test results to Test Users. No changes in the reporting medium shall be implemented without the prior written approval of the Battelle Contract Representative.

2. Notification of Lost Samples, Reporting Error, or Loss of Capability

The Contractor shall immediately (before the end of the business day) notify the Battelle Contract Representative orally of lost or inadvertently destroyed samples, errors in reporting, or the loss of a capability which may adversely affect analytical tests results or the delivery of analytical test reports within the times specified herein. Written confirmation shall be provided within 5 business days of the oral report. Whenever the Contractor determines that a correction should be made to a previously reported result, the correct result and reason for the correction shall be reported orally before the end of the business day to the Battelle Technical Administrator for Battelle orders or the Test User for other orders and confirmed in writing with the next scheduled report.

APPENDIX E

**COMPARISON OF AVAILABLE CODES FOR REMEDIAL
INVESTIGATION/FEASIBILITY STUDY**

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APPENDIX E

COMPARISON OF AVAILABLE CODES FOR REMEDIAL INVESTIGATION/FEASIBILITY STUDY

1.0 PURPOSE

Computer models and codes provide a framework to incorporate the processes that are active at a waste disposal site, thereby permitting assessment and evaluation of various waste management options for a given site. The time frames, ranging from decades to thousands of years, associated with evaluation of waste isolation potential for a given site also necessitate the use of models and codes.

- Because of the importance of the computer models relative to the performance assessment and risk assessment of a waste disposal site, a
- process to compare these codes has been developed. The codes must be
- compared to determine the limitations of theories and reliability of
- supporting empirical relations and laboratory tests used for evaluation of
- long-term waste isolation potential.

The purpose of this section is to provide a comparison of a variety of codes that are possible candidates for use in the remedial investigation/feasibility study (RI/FS) of a given site. The groundwater, air, biotic, direct contact, and surface-water pathways are considered for transport of contaminants. Such a comparison can be used to function in the following manners:

- • Provide a screening mechanism (i.e., to determine which codes are applicable to a specific requirement at a given site)
- • Indicate potential deficiencies of the codes
- Evaluate the necessity of additional codes that do not currently exist but might be required in the future for an RI/FS
- Provide a basis for gathering additional field data during site characterization.

2.0 SCOPE OF WORK

The codes compared in this report were selected as part of a two-step process. The first step in comparing the codes was to assemble the list of relevant codes that can potentially be used in an RI/FS. The second step was to prepare a table describing the important features of selected codes. As

part of the second step, a detailed comparison of the selected codes was performed and a comparison table was developed.

The criteria used in assembling the list of codes may be summarized as follows.

- Codes developed and used by the U.S. Department of Energy (DOE), U.S. Nuclear Regulatory Commission (NRC), and U.S. Environmental Protection Agency (EPA) should be selected.
- These codes should be:
 - Unclassified
 - Off-the-shelf
 - Documented sufficiently to make preparation of an evaluation feasible.
- If codes are available in several versions, the most recent should be used.
- The total number of codes reviewed must be consistent with schedule and manhours available.

Furthermore, the comparison process should address the following:

- Stage of development of the code
- Verification and benchmark status
- Validation status
- Availability of users' manual
- Acceptance by regulatory agencies (i.e., code usage by the DOE, NRC, and EPA)
- Acceptance by the scientific community (i.e., availability of peer-reviewed journal articles incorporating code description and verification and benchmark results)
- Operational readiness status of the code at the Hanford Site
- Cost of using the code
- Strengths of the code
- Limitations
- Input data required

- Availability of preprocessors and postprocessors for a code
- Ability (or inability) to model Hanford Site conditions; in particular, ability to model the dry, heterogeneous vadose zone soils at the Hanford Site
- Hardware requirements for a code
- Expertise required to use a code
- Marginal advantage of one code over another.

The comparisons are based on available publications and documentation of the codes, supplemented in some cases by the experience of members of the Environmental Technology Group. The comparisons are not comprehensive; rather, the goal was to indicate how the codes might be used in RI/FS analysis and point out the deficiencies in the codes. These comparisons, therefore, represent a first step in the screening process for using a code for a given site.

Table E-1 provides a comparison table for integrated transport codes. Table E-2 describes several groundwater pathway codes. Table E-3 describes transport codes for the air, biotic, and direct-contact pathways.

Table E-1. Integrated Models for All Pathways. (sheet 1 of 2)

Computer code name	Stage of development	Verification/benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/another
RAPS/MEPAS (model to simulate contaminant transport from a waste disposal site and to evaluate human exposure)	Fully developed	Verified and benchmarked (Whelan et al. 1987)	Not validated	Yes (Whelan et al. 1986)	U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA)	Unknown	Available on site Pacific Northwest Laboratory (PNL)	Low	Minimum knowledge of risk assessment and a minimum amount of input data; considers ground-water, overland, surface water, and atmospheric pathways	Can be used to rank or prioritize sites; but cannot be used in a predictive mode to simulate actual risks at a particular site from the release of contaminants	Dispersion coefficients, hydraulic conductivities, degradation rates, modes of exposure, and dose response information	No	Unknown	Micro/mini-computer	Familiarity with users' manual	Can be applied to rank or prioritize sites; includes simplified models for risk assessments to important receptors
PATHRAE (simulates transport from ground-water, surface water, atmospheric, and occupational pathways)	Fully developed	Unknown	Not validated	Yes (Rogers and Hung 1987)	DOE/U.S. Nuclear Regulatory Commission (NRC)	Unknown	Available on site (PNL)	Low	Minimum user knowledge of risk assessment and a minimum amount of input data; considers complex processes migration, degradation, transformation, transfer between media (air, water, etc.) and biological uptake	Can be used to rank or prioritize sites, but cannot be used in a predictive mode to simulate actual risks at a particular site from the release of contaminants	Dispersion coefficients, hydraulic conductivities, degradation rates, modes of exposure, and dose response information	No	Unknown	Micro/mini-computer	Familiarity with users' manual	Can be applied to rank or prioritize sites; includes simplified models for risk assessments to important receptors

Table E-1. Integrated Models for All Pathways. (sheet 2 of 2)

Computer code name	Stage of development	Verification/benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/another
GEMS (EPA library of codes to model each potential transport pathway)	Fully developed	Unknown	Unknown	Yes (GSC 1982)	EPA	Unknown	Not currently available on site	Medium to high	Unknown	Unknown	Dispersion coefficients, hydraulic, conductivities, degradation rates, modes of exposure, and dose response information	Yes	Unknown	Terminal and modem to access GEMS	Limited modeling experience and familiarity with users' manual	EPA model

Table E-2. Available Groundwater Pathway Computer Codes for Remedial Investigation/Feasibility Study. (sheet 1 of 4)

Computer code name	Stage of development	Verification/benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/another
CHAINT (2D transport code for saturated and unsaturated media; includes radionuclide decay and adsorption for contaminants)	Fully developed	Partially verified and benchmarked	Not validated	Yes	DOE	Unknown	Available on PRIME 750	Medium	Low cost for vadose zone flow simulation, two-dimensional transport	One-dimensional, vertical, steady-state unit gradient model for vadose zone, does not allow for source/sink terms	Soil moisture characteristics for various layers	Yes	Applied to 200 Areas solid waste disposal sites	Mini/mainframe computers	Familiarity with users' manual, theory description	Low cost of simulation, Westinghouse Hanford Company personnel familiarity with codes, less data requirements
MAGNUM (2D code for simulated groundwater flow in saturated aquifers)	Fully developed	Verified and benchmarked	Not validated	Yes	DOE	Unknown	Available on PRIME 750	Medium	Two-dimensional flow simulations	Does not allow for source/sink terms within aquifers	Hydraulic characteristics for various zones with aquifers	Yes	Extensively applied to Hanford Site basalt aquifers (flow tops and dense interiors)	Mini/mainframe computers	Familiarity with users' manual, theory description	Low cost of simulation, Westinghouse Hanford Company personnel familiarity with code. MAGNUM was especially developed for modeling flow in basalt environment
FEMWATER/FEMWASTE	Fully developed	Verified and benchmarked (Yeh et al. 1987)	Not validated	Yes	DOE		Not available on site	High	Two-dimensional flow and transport includes vadose zone/sinks	Long execution times, inability to model heterogeneous vadose zone soils	Moisture characteristic curves for various vadose zone layers	No	Unknown	Mini/mainframe computers	High degree of familiarity with theory and users' manuals	Integrated saturated/unsaturated zone modeling flow including sources/sinks for unconfined aquifer

Table E-2. Available Groundwater Pathway Computer Codes for Remedial Investigation/Feasibility Study. (sheet 2 of 4)

Computer code name	Stage of development	Verification/benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/another
VAM2D/SATURN (2D flow and transport code for saturated/unsaturated media; includes decay and adsorption)	Fully developed	Verified and benchmarked (Huyakorn et al. 1984)	Not validated	Yes	U.S. Department of Energy (DOE) U.S. Nuclear Regulatory Commission (NRC)	Huyakorn et al. 1984, 1985, 1987		Medium	Includes a simplified option for modeling vadose zone; includes option sources/sinks for aquifers	Long execution times, for the full saturated/unsaturated flow and transport modeling	Hydraulic characteristics for various vadose zone layers and unconfined aquifers	No	Capable of modeling heterogeneous layered media (such as those existing at Hanford Site)	Mini/mainframe computers	High degree of familiarity with theory and users' manuals	Simplified option for vadose zone modeling; option for including sources/sinks for unconfined aquifer; integrated modeling of saturated/unsaturated media
TRACR3D (3D code for modeling flow and transport of multiphase organics in vadose zone)	Fully developed	Currently being verified and benchmarked at Pacific Northwest Laboratory (PNL) for the Hanford Site grout program	Not validated	Yes, (Travis 1984)	DOE, NRC	Unknown	Available at PNL	High	Multi-dimensional modeling of flow and transport of organics	Does not include flow and transport in unconfined aquifer; limited ability to model heterogeneous vadose zone properties	Relative permeability versus saturation relationships for various multiphase organics	No	Has difficulty in simulating flow through heterogeneous layered media (such as those existing at Hanford Site)	Mini/mainframe computers	High degree of familiarity with theory and users' manuals	Ability to model multi-dimensional, multiphase flow and transport in vadose zone
PORFLO (3D code for simulating flow, heat transport and mass transport saturated porous media)	Fully developed	(Eyler and Budden 1984)	Not validated	Yes, (Kline et al. 1983)	DOE	Unknown	Available onsite	Medium	Three-dimensional simulations possible; allows for sources/sinks in unconfined aquifers	Vadose zone simulation capabilities not available but are currently being incorporated	Hydraulic properties of various heterogeneities in the saturated aquifer	Yes	Extensively applied to model flow and transport through Hanford Site basalts	Mini/mainframe computers	High degree of familiarity with theory and users' manuals	Ability to model three-dimensional flow and transport in saturated media, Westinghouse Hanford Company familiarity with code
MODFLO (3D code for simulating flow in saturated porous media)	Fully developed	(McDonald and Harbaugh 1984)	Not validated	Yes	U.S. Geological Survey	Unknown	Not available onsite	Medium	Modular structure of various submodels	Vadose zone simulation capabilities not available	Hydraulic properties of saturated confined and unconfined aquifers	No	Unknown	Mini/mainframe computers	Familiarity with users' manual	Ability to model three-dimensional flow in saturated media

Table E-2. Available Groundwater Pathway Computer Codes for Remedial Investigation/Feasibility Study. (sheet 3 of 4)

Computer code name	Stage of development	Verification/benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/another
VAM3D (3D flow and transport code for modeling flow and transport through saturated/unsaturated media; includes decay and adsorption)	Fully developed	Verified and benchmarked (Huyakorn et al. 1985)	Not validated	Yes	DOE	Unknown	Not available on site	Verify high	Includes a simplified option for modeling vadose zone; includes option for incorporating source/sink terms in aquifers	Very long execution times for modeling the full, 3D, saturated/unsaturated media	Hydraulic properties for various vadose zone layers and unconfined aquifers	No	Capable of modeling heterogeneous layered media (such as those existing at Hanford Site)	Mainframe computer	Very high degree of familiarity with theory and users manuals	Ability to the full, 3D flow and transport in an integrated saturated/unsaturated media, with sources/sinks in unconfined aquifers
UNSAT2	Fully developed	Verified and benchmarked	Not validated	Yes	DOE/NRC	(Neuman 1973)	Available at PNL	Medium	Two-dimensional vadose zone and unconfined aquifer simulations with sources/sinks present in unconfined aquifer	Vadose zone flow simulation capabilities limited to simpler, smaller flow domains; does not include contaminant transport modeling option	Hydraulic properties for various vadose zone layers and unconfined aquifers	No	Has difficulty in simulating flow through heterogeneous, layered media (such as those existing at Hanford Site)	Mini/mainframe computer	High degree of familiarity with theory and users manuals	Ability to model 2D in integrated saturated/unsaturated media, with sources/sinks in unconfined aquifers
UNSAT-H (1D model for simulating flow through vadose zone)	Fully developed	Verified and benchmarked	Not validated	Yes, (Fayer 1987)	DOE	Unknown	Available at PNL	Low	Developed specifically for Hanford Site conditions; includes a water balance subroutine	One-dimensional model, limited applicability to multi-dimensional, heterogeneous layered media	Soil properties, plant data for ET calculations	Unknown	Capable of simulating flow in heterogeneous layered media	Mini/mainframe computer	Familiarity with users manual	Has been applied to Hanford Site conditions

Table E-2. Available Groundwater Pathway Computer Codes for Remedial Investigation/Feasibility Study. (sheet 4 of 4)

Computer code name	Stage of development	Verification/benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/another
RITZ (simulates movement fate of hazardous chemicals during land treatment of oily wastes)	Fully developed	Unknown	Not validated	Yes, (Nofziger and Williams 1988)	U.S. Environmental Protection Agency (EPA)	Unknown	Available onsite	Low	Simple model with few data requirements; can be applied in case of organics	Assumptions are highly simplistic and may not be valid in nature; cannot be used to simulate actual risks at a site	Input data on soil, pollutant, oil, environmental, and operational parameters for land treatment sites	Yes	Unknown	Micro-computer	Familiarity with users' manual	Can be applied to obtain preliminary data on transport and fate of organics in the vadose zone
SESOL (unsaturated zone transport model)	Fully developed	Unknown	Not validated	Yes, (Bonaountas and Wagner, 1981)	EPA	Unknown	Available through GEMS	Low - Medium	Models organic and inorganic species; accounts for adsorption, volatilization, degradation, and biodegradation	Only handles up to three soil layers	Hydrologic and meteorologic data, contaminant information	Yes	Unknown	Terminal and modem access to GEMS	Familiarity with users' manual	Versatile, easy to use, EPA acceptance
HELP (1-D unsaturated flow and transport model)	Fully developed	Unknown	Not validated		EPA	Unknown	Available onsite	Low	Simple model for rough calculations, models organic and inorganic species	Simple 1-D approach may not be adequate at some sites	Hydrologic and meteorologic data, contaminant information	No	Yes	IBM-PC or equivalent	Familiarity with users' manual	Easy to use, EPA acceptance

Table E-3. Transport Codes for the Air, Biotic, and Direct Contact Pathways. (sheet 1 of 3)

Computer code name	Stage of development	Verification/benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/another
AIR PATHWAY TOXBOX (basic box model)	Fully developed	Unknown	Unknown	(GSC 1982)	U.S. Environmental Protection Agency (EPA)	Unknown	Not currently accessible at Hanford Site	Low-Medium	Can represent vertical dispersion; areal source; available through GEMS	Simplified box model	Unknown	Yes	No site-specific limitations	Terminal and modem to access GEMS	Limited modeling experience	Ease of use and EPA acceptance
INDUSTRIAL SOURCE COMPLEX (Gaussian dispersion model)	Fully developed	Unknown	Unknown	(GSC 1982)	EPA	Unknown	Not currently accessible at Hanford Site	Low-Medium	Long- and short term simulations; settling and dry deposition of particles; multiple point sources; limited terrain adjustments	Unknown	Meteorological and source data	Yes	No site-specific limitations	Terminal and modem to access GEMS; mini/mainframe computer	Limited modeling experience	Rigorous approach and EPA acceptance
SEE ALSO PATHRAE AND RAPS/MEPAS																

Table E-3. Transport Codes for the Air, Biotic, and Direct Contact Pathways. (sheet 2 of 3)

Computer code name	Stage of development	Verification/benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/another
BIOTIC PATHWAY																
BIOPORT/ MAXI 1 (Radiation dose due to plants and animals)	Fully developed	Planned for FY 1989	Planned for FY 1989	(McKenzie et al. 1985)	NRC	Unknown	Available at Hanford Site	Low	Radiation dose calculated for ingestion, inhalation, and direct exposure; intrusion and active physical transport are considered	Does not consider hazardous chemicals	Agricultural and water-use practices; wildlife information	No	No site-specific limitations	Mini/mainframe computer	Limited modeling experience	Developed at Hanford Site
SEE ALSO PATHRAE AND RAPS/MEPAS																
DIRECT-CONTACT PATHWAY																
ONSITE/ MAXI 1 (Radiation dose due to direct intrusion)	Fully developed	Unknown	Unknown	(Kennedy et al. 1986, 1987)	NRC	Unknown	Available at Hanford Site	Low	Radiation dose calculated for direct exposure and ingestion (food and water)	Does not consider hazardous chemicals	Agricultural and water-use practices; lifestyle characteristics of intruder/resident	No	No site-specific limitations	Micro/mini/mainframe computer	Limited modeling experience	Developed at Hanford Site
SEE ALSO PATHRAE AND RAPS/MEPAS																

Table E-3. Transport Codes for the Air, Biotic, and Direct Contact Pathways. (sheet 3 of 3)

Computer code name	Stage of development	Verification/benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/another
SURFACE WATER PATHWAY EXPOSURE ANALYSIS MODELING SYSTEM (3-D compartmental model for freshwater, nontidal systems)	Fully developed	Unknown	Unknown	(Burns et al. 1982) (GSD 1982)	EPA	Unknown	Not currently accessible at Hanford	Medium-High		Unknown	Unknown	Yes	No site-specific requirements	Mini/mainframe computer	Understanding of transport process and modeling experience	Rigorous approach and EPA acceptance
WATER QUALITY ASSESSMENT METHODOLOGY (1-D Model for lakes, rivers, and streams)	Fully developed	Unknown	Unknown	(Mills et al. 1982)	EPA	Unknown	Not currently accessible at Hanford	Low	Easy to use with desk calculator	Very simple approach	Limited data requirements	No	No site-specific requirements	Calculator	Limited modeling experience	Ease of use and EPA acceptance
SEE ALSO RAPS/MEPAS AND PATHRAE																

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APPENDIX F

**DESCRIPTION OF APPLICABLE TECHNOLOGIES AND WASTE
TREATABILITY STUDY REQUIREMENTS FOR 1100-EM-1
OPERABLE UNIT**

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APPENDIX F

DESCRIPTION OF APPLICABLE TECHNOLOGIES AND WASTE TREATABILITY STUDY REQUIREMENTS FOR 1100-EM-1 OPERABLE UNIT

This appendix describes technologies applicable to the 1100-EM-1 operable unit. The bases for selecting these technologies from all available technologies were the following.

- (1) The technologies selected needed to have established procedures.
- (2) They needed to be applicable to the anticipated types of waste and the soil and groundwater conditions of the 1100 Area.

No new or innovative technologies were included. The information present for each technology includes a process description, design models, design parameters, other factors affecting performance, a brief description of the type of treatability tests likely to be conducted, and bibliography and references used to develop this information.

1.0 ACTIVATED CARBON

Carbon adsorption is a separation technique for removing a variety of organics including dissolved organics from wastewater. Pilot-plant and full-scale tests have been performed using di-n-octyl phthalate, bis(2-ethylhexyl) phthalate, and some polyvinylchloride mixtures. Carbon adsorption can also be used to separate some inorganics, as a treatment following precipitation and/or oxidation-reduction units. Pilot- and full-scale tests have been performed for chromium and arsenic.

1.1 PROCESS DESCRIPTION

Wastewater containing the contaminants of concern is passed through a bed of granular activated carbon (GAC). The contaminants are adsorbed until the GAC adsorption capacity is exhausted. The GAC can then be regenerated or incinerated. In a typical adsorption system, several beds are operated in series with the first bed being taken out of service once contaminant breakthrough occurs, and a regenerated bed is added to the last stage.

1.2 DESIGN PARAMETERS

Wastewater flow rate (m^3/h)
Service time (h)
Bed depth (ft)
Hydraulic loading (linear velocity of fluid) (ft/h)

Concentration of impurity in influent (mg/L)
Concentration of impurity in effluent (mg/L)
Adsorption efficiency (mg/L)
Adsorption rate constant (L/mg·h).

1.3 OTHER EFFECTS

Temperature--Increasing temperature increases adsorption rate but decreases adsorption capacity.

Suspended solids--These clog carbon pores causing inefficient operation. Suspended solids are generally limited to 50 mg/L. Upflow operation can minimize the problem.

Oil and grease--These can clog carbon pores. Oil and grease are generally limited to 10 mg/L.

Species selectivity--Adsorption of one species may inhibit the adsorption of another species.

Regeneration offgas--Some organic species such as polychlorinated biphenyls are not destroyed at regeneration temperatures and may require special handling.

1.4 DESIGN MODELS

The design of a full-scale adsorption system requires surface-loading-rate and bed-volume information. These design parameters are determined by performing pilot-scale adsorption tests. Several design models have been developed over the years describing both single-solute and multisolute adsorption. To predict multisolute adsorption in a continuous flow adsorption, adsorption information and adsorption kinetic information must first be collected. The single-solute adsorption information is obtained by the static "bottle-test" procedure, and the kinetic information can be obtained by either batch or minicolumn experiments (Crittenden 1978a). The most popular continuous flow, predictive models are the MADAM and HSDM (Crittenden 1978b). Both models have been shown to yield reliable results under certain system conditions. Although the use of these models is not necessary for full-scale design, they afford a degree of design and operation flexibility that is well worth the effort of implementation.

1.5 WASTE TREATABILITY DETERMINATION

Bench-scale batch tests are conducted to develop equilibrium adsorption isotherms for various types of GAC to select the one with the best performance for the anticipated wastewater composition. Column tests are conducted using a system of three or more columns arranged in series with depth and flow rate in the range expected to determine the total bed depth and service time of a single column. Tests are also conducted to determine backwash

requirements to remove suspended solids collected by the bed. Carbon regeneration tests are conducted to determine regeneration requirements and to estimated carbon loss per each regeneration. The offgas is characterized for any contaminants present requiring special disposal requirements.

1.6 REFERENCES

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2.0 CERAMIC MELTER

Ceramic melter technology has been developed for treating radioactive wastes to provide for their long-term isolation. These wastes consist largely of mixtures of radionuclides and heavy metals. Application of melter technology to remediation of hazardous wastes appears very promising. Hazardous organic wastes are destroyed in the high temperatures of the glass furnace. The residual ash as well as hazardous noncombustibles (heavy metals) are incorporated into a durable (highly nonleachable) glass waste form for disposal. Bench-scale testing has demonstrated the capability for vitrification of contaminated soils with the addition of glass-forming chemicals to produce a quality waste form. Present testing is investigating the use of mechanical stirring as a means of improving waste contact with the glass melt. Further treatability tests are desirable to determine the destruction efficiencies achievable for soils contaminated with a variety of hazardous organic compounds; thus, this demonstrates the inherent flexibility of the process. Leach testing of the glass waste form to determine isolation of heavy metal contaminants is expected to give excellent results.

2.1 PROCESS DESCRIPTION

The ceramic melter system consists of a feed-delivery system, a melter unit, a glass-discharge system, and an offgas-treatment system. The melter is constructed of refractory materials surrounding the melt cavity, all contained within a metal box. Current is passed between opposing electrodes, and the glass acts as a resistance element to provide for joule heating of the melt. The melt is maintained at temperatures of about 1150 °C, and the plenum space above the melt is about 800 °C. Wastes are fed directly into the melt chamber where they react with glass-forming materials at high temperatures; the organic species are destroyed and the inorganics dissolve into the melt. Periodically, glass is poured from the melter into receiving canisters and allowed to cool. The offgas from the melter is treated by a system similar to that for conventional incinerators.

2.2 DESIGN PARAMETERS

Waste feed rate (kg/h)
Waste feeding technique (stirring, cold cap, bubbler)
Glass temperature (°C)
Plenum temperature (with or without plenum heating) (°C)
Offgas temperature (°C)
Concentration of contaminant in feed (%)
Concentration of contaminant in offgas (%)
Leach characteristics of product glass (%).

2.3 OTHER EFFECTS

Insoluble inorganics--Some insoluble inorganic species, such as slag, will form a second phase that may not have the desired leachability characteristics.

Volatile inorganics--Some volatile inorganics, such as mercury, will carry over with the offgas and require subsequent treatment.

2.4 DESIGN MODELS

The ceramic melter process is a combination of glass formulation and incineration. The key design correlations for glass formulation can be found in numerous texts to obtain desirable glass viscosity, inorganic contaminant solubility, and electroconductivity. Generally, the glass characteristics are very tolerant of changes in the formulation during operation. The destruction efficiency of organic contaminants is generally fixed by the conditions of the glass melt. Any unconverted organics in the offgas can be further combusted either in an afterburner or by recycling a portion of the offgas to the melter. The amount of recycle can be determined by assuming a percent conversion per pass to the bed and performing a material balance around the melter.

2.5 WASTE TREATABILITY DETERMINATION

Bench-scale melter testing would be conducted by processing soils with the contaminants of interest (heavy metals, solvents, oils, pesticides, etc.). Glass-forming chemicals would be added to produce a quality glass product. Offgas sampling would be conducted to establish the destruction and removal efficiencies of the process. Critical parameters (e.g., feed rate, feed technique, temperatures) would be adjusted to determine their effect on destruction and removal efficiencies. Tradeoffs would be examined to determine the optimal operating parameters for the hazardous waste application of interest. Data would be collected to determine the extent of effluent treatment and recycle requirements. Larger-scale testing (engineering- or pilot-scale) would be performed to confirm scale-up design factors.

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3.0 CHEMICAL OXIDATION-REDUCTION

Chemical oxidation processes are those processes in which a chemical oxidizing or reducing agent is added to the wastewater to change the valence state of the target constituent to a less hazardous form. Common oxidizing agents include chlorine gas (plus caustic), calcium and sodium hypochlorate, chlorine dioxide, potassium permanganate, hydrogen peroxide, and ozone (either alone or in combination with ultraviolet radiation).

Chemical oxidation processes are suitable for organics (acids, aldehydes, mercaptans, phenols, polynuclear aromatic hydrocarbons, pesticides, polychlorinated biphenyls, and other halogenated organics), cyanides, ammonia, and some metals (iron, manganese, and selenium). Chemical reduction is suitable for a variety of metals including chromium, mercury, lead, silver, nickel, copper, and zinc. Metal-cyanide complexes can be treated by oxidizing the cyanide and then reducing the metal.

3.1 PROCESS DESCRIPTION

In a typical oxidation-reduction process wastewater and chemical reagents are combined under ambient conditions in a batch or continuous reactor equipped with rapid-mix agitators and monitored with an

oxidation-reduction probe and a pH probe. Treated effluent is discharged for further treatment to remove any residues and treat any hazardous byproducts generated.

3.2 DESIGN PARAMETERS

Reactor configuration
Wastewater flow rate (m^3/d)
Chemical reactant and dosage (kg/L)
Contact time (h)
pH.

3.3 OTHER EFFECTS

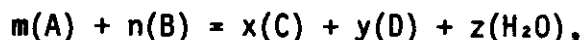
Nonspecificity--Chemical oxidation and reduction reactants are not selective. Thus, other constituents will cause a greater chemical reagent demand.

Reactant residuals--Residual chlorine, ozone, or sulfites can damage downstream equipment and should be neutralized.

Partial oxidation of organics--Oxidation of organics is not always carried to completion. Thus, organic byproducts that are hazardous will possibly be produced.

3.4 DESIGN MODELS

Given the generalized reaction:



the reaction rate is governed by the rate equation:

$$d(A)/dt = K_1(A)^m(B)^n - K_2(C)^x(D)^y$$

where

K_1 and K_2 are reaction rate constants and
 $K_1/K_2 = K_{eq}$ (equilibrium constant).

3.5 WASTE TREATABILITY DETERMINATION

Laboratory tests are conducted to identify a suitable reagent, dosage, and optimum pH environment and to measure the time required to achieve

complete reaction. These test can be performed in stirred beakers of wastewater monitored for pH and oxidation-reduction potential.

3.6 BIBLIOGRAPHY

EPA, 1983, *Treatability Manual*, EPA-600/2-82-001, U.S. Environmental Protection Agency, Washington, D.C.

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4.0 FILTRATION

Filtration is a physical separation process used to reduce the moisture content and volume of chemical and biological sludges. Processes include vacuum filtration, centrifugation, and pressure filtration. The specific type of filtration selected will depend on the solid and liquid loading characteristics of the slurry requiring dewatering.

4.1 PROCESS DESCRIPTION

There are several types of vacuum filters available commercially. The rotating drum is one type commonly used in dewatering operations. The drum, which has vacuum applied inside, rotates through the slurry in the submergence portion. Retained solids are dried in the remaining portion of the drum as air is drawn through the cake. The cake is continuously removed from the drum surface and packaged for disposal or further treated as necessary.

In centrifugal filtration, slurries are introduced into a rapidly rotating unit. Solids are forced against the wall at up to 6,000 times the force of gravity. These solids are then removed for packaging or further treatment.

There are also several types of pressure filtration units including filter presses. These are typically batch operations in which a slurry is forced against a filter at differential gage pressures of up to 225 lb/in². Water is collected on the other side of the filter as solids are retained on the filter. Once the filter is fully loaded, flow of slurry to the unit is stopped and the solids removed for packaging of further treatment.

4.2 DESIGN PARAMETERS

Influent flow (L/d)
Influent sludge (kg/d)

Concentration of solids (%)
 Filter loading ($\text{kg/m}^2 \cdot \text{h}$)
 Filter area (m^2)
 Pressure (lb/in^2)
 Cake solids (%)
 Chemical dosage (polyelectrolyte) (mg/L).

4.3 DESIGN MODELS

$$t/V = [(\mu r c)/(2PA^2)]V + \mu R_m/PA$$

$$r = r_0 P^s$$

where

t = time
 V = volume
 μ = viscosity
 r = specific resistance
 c = solids deposited per unit volume
 P = applied vacuum
 A = filtration area
 r_0 = cake constant
 s = compressibility.

4.4 WASTE TREATABILITY DETERMINATION

Laboratory-scale tests can be used to determine the design parameters for filtration. Specifically, Buchner funnel or leaf-filter tests are conducted with 1-L volumes of slurry. Because filtering characteristics are dependent on slurry history, these tests should be conducted with slurries formed at reaction temperatures anticipated during actual operation. In addition, the filtration aids and slurry or sludge age should be similar to that used in actual operations.

There are a series of Buchner funnel tests that are used to determine specific resistance, the effect of adding a flocculent, the cake constant, and sludge compressibility. At a given vacuum pressure and filter area, the rates of filtrate and solids loading are determined. From these data the t/V versus V relationship can be determined; the slope of the curve on which t/V is plotted as a function of corrected volume allows calculation of the specific resistance. (Corrected volume is the total volume of filtrate minus the volume of filtrate collected before a cake is formed.) In another test, additional information on the effectiveness of a chemical conditioner (such as a polymer to improve flocculation) can be obtained by measuring the change in specific resistance at different concentrations of the chemical conditioner. The solids concentration in the sludge is kept constant for this test. In a third set of tests, the vacuum pressure is varied, the specific resistance is calculated, and pressure versus resistance is plotted. The

slope of this curve is the compressibility coefficient and the intercept is the cake constant.

From the Buchner funnel tests, a determination of the type of filtration (i.e., vacuum, centrifugal, or pressure) can be made based on slurry characteristics. A guideline used in industry characterizes the slurry as fast, medium, or slow according to the cake buildup rate. If a cake is formed at a rate on the order of cm/s, filtration rates are rapid; clarification alone would be sufficient for solid/liquid separation. If the cake buildup is 0.05 to 5.0 cm/h, the cake forms at a medium rate; vacuum filtration could be used. If the cake buildup rate is 0.10 to 5.0 cm/h, the filtering rate is slow and pressure filtration would be required. For cake buildup rates between the medium and slow rates defined above, centrifugation is recommended. Specific tests for each type of filtration can then be performed if adequate information on the slurry characteristics is not available in the literature.

4.5 BIBLIOGRAPHY

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5.0 TRICKLING FILTERS

A fixed-film biological treatment process is a process in which a fixed microbial population is used to biodegrade the organic and nitrogenous components of the wastewater stream. The process is used to remove organic material from a wastewater stream by converting it into innocuous gases and microbial slime. Excess slime is carried with the effluent and is separated from the treated water in a gravity clarifier. Fixed-film biological treatments include trickling filters and rotating biological contactors. Pilot-scale data have been obtained for bis(2-ethylhexyl) phthalate in a trickling filter. The polychlorinated biphenyls are generally resistant to biodegradation in these systems. Fixed-film biological treatment processes are tolerant of fluctuations in the organic loading of wastewater.

5.1 PROCESS DESCRIPTION

Trickling filters consist of a suitable structure packed with an inert medium, such as rock, on which a biological mass is grown. Wastewater is distributed over the top of the medium. As the wastewater trickles through the medium the dissolved and suspended organic matter is sorbed on to the

packing medium and oxidized by the organism. Air percolates through the medium by convection to provide oxygen needed to maintain aerobic conditions. During operation the slime layer of microorganisms thickens, periodically sloughs off, and is carried out with the effluent to a clarifier where the agglomerated solids are settled and removed.

5.2 DESIGN CRITERIA

Wastewater flow rate (gal/d)
 Hydraulic loading rate ($\text{m}^3/\text{d}\cdot\text{m}^2$)
 Recirculation ratio
 Bed depth (m)
 Temperature ($^{\circ}\text{C}$)
 Organic loading rate ($\text{kg BOD}/\text{m}^2\cdot\text{d}$).

5.3 DESIGN EQUATIONS

$$S_e/S_o = e^{-KZ/Qa^n} \quad (\text{general})$$

$$S_e/S_o = \frac{e^{-KZ/Qa^n}}{1 + R - R e^{-KZ/Qa^n}} \quad (\text{recirculating}).$$

5.4 WASTE TREATABILITY DETERMINATIONS

1. Set up full-depth column with filter media of interest (stone, saddles, etc.). This is a pilot-scale unit with no bed depth scale-up.
2. Operate column at three or more hydraulic loadings.
3. Plot $\ln S_e/S_o$ versus depth (Z).
4. Plot \ln slope of previous plots versus \ln hydraulic loading (Qa).
5. Constants to be determined are the reaction rate (K) and media character constant (n).

5.5 BIBLIOGRAPHY

EPA, 1983, *Treatability Manual*, EPA-600/2-82-001, U.S. Environmental Protection Agency, Washington, D.C.

BOD = biochemical oxygen demand.

6.0 ROTATING BIODISCS

A fixed-film biological treatment process is a process in which a fixed microbial population is used to biodegrade the organic and nitrogenous components of the wastewater stream. The process is used to remove organic material from a wastewater stream by converting it into innocuous gases and microbial slime. Excess slime is carried with the effluent and is separated from the treated water in a gravity clarifier. Fixed-film biological treatments include trickling filters and rotating biological contractors. Pilot-scale data have been obtained for bis(2-ethylhexyl) phthalate in a trickling filter. The polychlorinated biphenyls are generally resistant to biodegradation in these systems. Fixed-film biological treatment processes are tolerant of fluctuations in the organic loading of wastewater.

6.1 PROCESS DESCRIPTION

Rotating biological contractors consist of a series of closely spaced plastic disks mounted in a contoured-bottom tank containing wastewater so that the disks are partially immersed. As the disks rotate, slime that builds on the disks is exposed alternately to wastewater and air. Excess slime is stripped off by rotational shear forces and eventually carried away with the treated wastewater to a clarifier.

6.2 DESIGN CRITERIA

Wastewater flow rate (gal/d)
Organic loading rate (kg BOD/m²·d)
Hydraulic loading rate (m³/d·m²)
Contractor surface area (m²)
Rotational velocity (w/s).

6.3 DESIGN EQUATIONS

$$\begin{aligned} Se/So &= (1 + K_1 at)^{-1} && \text{(general)} \\ Se/So &= (1 + K_1 at)^{-n} && \text{(in series).} \end{aligned}$$

6.4 WASTE TREATABILITY DETERMINATIONS

1. Set up full-diameter disc/vat with reduced number of discs (pilot scale).
2. Vary detention time.
3. Plot Se/So versus area-time; slope is mass transfer coefficient (K_1). Intercept should be one.

6.5 BIBLIOGRAPHY

EPA, 1983, *Treatability Manual*, EPA-600/2-82-001, U.S. Environmental Protection Agency, Washington, D.C.

7.0 AIR/STEAM STRIPPING

Air stripping and steam stripping are mass transfer processes based on vapor/liquid equilibrium that use a gas (air or steam) to separate volatile organic compounds from wastewater. Air stripping is generally used to treat wastewater containing volatile organics that are only slightly water soluble. The organic-laden air stream is further processed to strip the organics from the airstream. Steam stripping differs from air stripping in that elevated temperature is used.

7.1 PROCESS DESCRIPTION

The air stripping process considered most suitable for wastewater treatment consists of a counter-current packed column that provides a large wetted contact surface for the air. Wastewater is distributed over the top of the packing and flows downward by gravity. Air is blown upward through the wetted packing, stripping organics from the falling wastewater. Treated wastewater is discharged from the bottom of the column and air saturated with organics and moisture is discharged from the top.

Steam stripping processes operate in much the same way as air stripping columns, except that distillation trays may be used instead of packing to achieve the desired contact surface of wastewater. A steam stripping column is always followed by a condenser that condenses the vapor effluent from the stripping column into a concentrated waste stream.

7.2 DESIGN PARAMETERS

Air stripping

- Wastewater flow rate (L/h)
- Column diameter (m)

Steam Stripping

- Wastewater flow rate (L/h)
- Column/tower diameter (m)
- Steam/wastewater ratio (kg/kg)
- Packed bed depth/tower height (m)
- Packing material/plate configuration
- Packing spacing (mm)
- Column temperature (°C)
- Pressure drop (mm of water/m)
- Wastewater pH

Vapor/liquid equilibrium data of key components at design column
Temperature
Plate efficiency (%).

7.3 OTHER EFFECTS

Calcium--Pretreatments using lime, such as a precipitation process, can produce scale deposits in air strippers.

Suspended solids and nonaqueous organics--Suspended solids and nonaqueous organics can foul packed columns.

Ambient temperature--Air will saturate with water in the column. This water can condense out at lower ambient temperatures and lead to contaminated condensate or ice.

Multicomponent mixtures--Binary vapor/liquid equilibrium data for multicomponent mixtures do not accurately predict column performance.

Azeotropes--Some organics may have azeotropes with water at higher concentrations than in the wastewater precluding stripping operations.

7.4 DESIGN MODELS

Design equations can be found in numerous engineering texts under "gas absorbers" for air strippers and under "distillation columns" for steam strippers. Vapor/liquid data and Henry's constants for binary water/organic component mixtures can also be found in several texts or in commercially available process simulation codes such as ASPEN (Registered trademark of JSD Simulation Service Company).

7.5 WASTE TREATABILITY DETERMINATION

Bench-scale tests are conducted to measure liquid/vapor equilibrium data for the range of wastewater mixtures and column temperatures anticipated. Samples should be made to represent any pretreatment processing such as pH adjustment and solids removal.

7.6 BIBLIOGRAPHY

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8.0 CATALYTIC DESTRUCTION

Catalytic destruction is a process that employs a catalysts to convert hazardous organics in aqueous streams to innocuous gases. The process is a thermal destruction process that can be used to treat liquid wastes and sludges found at Superfund sites. The primary application of the process is for organic waste streams that are too dilute to incinerate and yet too toxic to biotreat. With most organic compounds, greater than 99% destruction is achieved. Chlorinated aromatic compounds can be destroyed by the process; however, catalyst deactivation is a problem. Proof-of-principle tests have been completed in a 1-L batch reactor and continuous processing experiments are currently in progress.

8.1 PROCESS DESCRIPTION

In the Pacific Northwest Laboratory catalytic destruction process, liquid waste streams containing organics are pumped to 2,000 to 4,000 lbf/in² (gage) and then passed through heat exchange equipment to heat the waste stream to 350 °C to 400 °C. The hot aqueous-organic steam enters the reactor where it is treated with a reduced nickel catalyst. The organic material is converted to innocuous gases, primarily methane and carbon dioxide, by a reduction reaction. No compressed air or oxygen is required for the conversion and no oxygenated pollutants are formed. The process requires only four unit operations: the catalytic reactor, pumping, heat exchange, and gas-liquid separation, making the process simple to operate. Conventional off-the-shelf equipment that is compact, reliable, and lends itself to the development of modular, transportable systems can be used.

The process is energy efficient because most of the preheat can be provided by heat exchange with the reactor effluent. Some auxiliary heat will be necessary and may be supplied by burning the product gases. If the organic content of the waste stream is 1% or more, it will provide sufficient fuel gas to heat the process. For concentrated organic streams, such as sludges, production of energy from the process as natural gas, electricity, or shaft power is possible.

8.2 DESIGN PARAMETERS

Temperature (°C)
Pressure (kPa)
Residence time (h)
Aqueous/organic ration (by weight).

8.3 OTHER EFFECTS

Catalyst lifetimes
Catalyst activity
Impurities.

8.4 DESIGN MODELS

Catalytic destruction is a chemical reaction; the rate of most reactions can be expressed as a function of temperature and composition. In practically all cases the temperature-dependent term can be well represented by Arrhenius' law:

$$k = k_0 e^{-E/RT}$$

where

k = the rate constant
k₀ = the frequency factor
E = the activation energy.

Many elementary reactions are first order with respect to the reactants and the rate equation can be integrated to the form

$$-\ln(1-XA) = kt$$

where

XA = the fractional conversion
t = the reaction time.

8.5 WASTE TREATABILITY DETERMINATION

A wide variety of organic materials have been tested including hexone, p-cresol, naphthalene, hexane, benzene, organic mixtures, trichloroethylene, and chlorobenzene. Results of these tests are available in the literature. If data on the specific organic compounds of interest are not available, batch reactor tests in a bench-scale high-pressure autoclave would supply the

necessary design information. Several tests would be required to determine the optimum temperature and the required residence time. Verification of this information in a continuous-flow reactor system should be done prior to design of the full-scale system. Facilities for both batch and continuous reactor tests are available at the CPDL at Pacific Northwest Laboratory.

8.6 BIBLIOGRAPHY

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9.0 ENCAPSULATION

The principal form of encapsulation used to isolate hazardous wastes uses cementitious grouts. Cementitious grouts are aqueous-based slurries containing cementitious materials that harden through hydration reactions. Grouts can be used for solidification of solid and liquid wastes and for encapsulation or stabilization of bulk solids and soils. Grout formulations have been developed for solidification of numerous waste types including high-salt liquid wastes, liquid wastes containing water-soluble organics, incinerator ashes, and mixed oxide powders. Chemical and mineral admixtures can be added to the grouts to improve processing characteristics, product quality, and long-term durability.

9.1 PROCESS DESCRIPTION

Liquid wastes can be solidified using either batch or continuous processing. The process is sufficiently flexible to allow widely varying waste streams to be processed and disposed of. In a typical continuous process (for monolithic, shallow-land disposal), liquid waste is mixed with a dry blend consisting of cement, fly ash, and clays to form a thin slurry. The slurry is pumped to a lined pit and allowed to harden. Once hardened, the monolith is covered with overburden. Alternatively, grouted waste can be cast into blocks or drums and placed in a landfill. Solid wastes can be processed in the same manner.

Grouts can also be used for encapsulation of bulk solids (e.g., for filling voids in a dump site). In this process, a sufficiently fluid grout slurry is injected into the site and subsequently flows into the voids. After hardening, the effective permeability of the site is reduced and transport of hazardous species is minimized.

9.2 DESIGN PARAMETERS

Grout Solids

Storage capacity (m^3)

Blender capacity (m^3)

Blending time (h)

Liquid (waste or water) Storage Capacity

Mixer

Mixer capacity (m^3)

Mixing time (h)

Shear rate (h^{-1})

Transfer System

Flow rate (m^3/h)

Pressure requirements (kPa).

9.3 OTHER EFFECTS

Waste composition--Certain anions, cations, and organic species can interfere with hydration reactions.

Temperature--Hydration reactions are highly dependent on temperature; low temperature can result in unacceptably long reaction times; extremely high temperatures can result in "flash set," which would result in process upsets.

Gas generation--Certain metals (e.g., zinc and aluminum) react to form hydrogen gas.

9.4 DESIGN MODELS

The formulation of grout is primarily an art in which general guidelines are used, along with laboratory and pilot-scale tests, to identify a suitable formulation to meet a given set of design specifications. Key considerations are the strength of the grout, the leachability of the contaminants, the size of the poured form, and the type of mixing process used. For large grout monoliths the heat release rate as the grout cures, which can be as high as 100 cal/g, may also be a consideration due to undesirable temperature profiles and a possible steam explosion hazard.

In general, grout formulations follow a basic recipe of four parts portland cement to one part water. This formula is adjusted to increase compressive strength and decrease contaminant leachability by decreasing the amount of water. In addition, the presence of accelerators, such as chlorides and most inorganic salts, or inhibitors, such as soluble organics, phosphates, and borates, in the waste to be grouted may have to be counteracted to achieve the desired curing rate. Also, the addition of other low-

continues to grow downward through the soil matrix until the desired depth is achieved. Volatile components in the soil pass through the fused soil and are collected under a hood that covers the vitrification site. Organics are thermally pyrolyzed to innocuous gases as they pass through the fused soil.

10.2 DESIGN PARAMETERS

Contaminant zone depth (m)
Contaminant zone geometry
Soil density (kg/m³)
Inorganic retention efficiency (%)
Organic destruction and removal efficiencies (%)
Migration into surrounding soil (% to surrounding soil, vitrified soil and offgas)

Electrical parameters

Soil resistivity (ohms)
Voltage (V)
Current (A)
Power input (kWh)
Energy/mass ratio (kWh/kg)

Offgas characteristics

Acid gas concentration (%)
Heavy metals concentration (%)
Organics concentration (%)

10.3 OTHER EFFECTS

Temperature--Melt temperature affects electrode life.

Groundwater--If the site to be treated penetrates into a shallow water table it may be necessary to use pumping stations to prevent recharging to the treatment zone during operation.

10.4 DESIGN MODELS

The primary design equation for in situ vitrification is Ohm's law:

$$E = IR$$

where

E = the applied voltage
I = the measured current
R = the resistivity of the soil.

cost materials such as fly ash may be used to adjust the curing rate and heat release rate for the grout.

9.5 WASTE TREATABILITY DETERMINATION

Laboratory-scale batch tests are conducted to develop a suitable grout formulation. An initial test uses a formulation based on the known composition of the waste, and the expected processing conditions (total volume, disposal method, and type of process used), but without additives. In subsequent tests the formulation is adjusted to achieve the desired strength, leachability, and curing rate.

A pilot-scale test using quantities ranging from approximately 30 to 2,000 gal is conducted to determine the effects of scale-up on grout slurry processing parameters and to verify the physical properties of the resultant grout solid. Some of the key parameters that are evaluated in pilot-scale tests include mixing efficiency, flow properties, and the effects of temperature gradients, hydrostatic pressure, and air entrainment on the grout properties.

9.6 BIBLIOGRAPHY

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10.0 IN SITU VITRIFICATION

In situ vitrification is a process for immobilizing contaminants in the soil by thermally fusing the contaminated soil. This process is particularly applicable to inorganic and certain organic contaminants.

10.1 PROCESS DESCRIPTION

Electrodes are imbedded to a predetermined depth in the contaminated soil matrix, and a graphite conducting path is spread between the electrodes at the surface. Once electric power is applied to the electrodes the soils surface melts and becomes the electric conductor. A block of fused soil

Correlations for electrical conductivity and viscosity to temperature can be found in the literature using tertiary diagrams for base soil and other key minerals such as sodium and calcium oxides.

10.5 WASTE TREATABILITY DETERMINATION

Waste treatability determination for in situ vitrification generally proceeds through three stages. A bench-scale test, using two electrodes separated by about 4 in., is conducted on an 8-kg soil sample representative of the site. Test results are evaluated to determine the voltage requirements of the power source. This parameter generally is used to determine treatability with respect to power source voltage capabilities. Preliminary data are also obtained on the migration effects of volatiles in the soil and offgas composition. The vitrified sample is evaluated for leachability. An engineering-scale test, using four electrodes spaced a foot apart in a 6-ft-dia chamber, is conducted to obtain the necessary data for designing a pilot-scale test. A pilot-scale test, using four electrodes 4 ft apart, is performed on approximately 6 ft³ of contaminated soil under unconstrained field conditions to verify performance, including migration of volatiles and offgas composition, and to determine scaling parameters for the full-scale system.

10.6 BIBLIOGRAPHY

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11.0 ION EXCHANGE

Ion exchange is a separation process that exchanges ions in solution with ions of like charge retained on an insoluble resinous solid called an ion-exchange resin. Ion-exchange resin has the ability to exchange either cations or anions. The exchangeable ions (typically H⁺ or Na⁺ in the cases of cation exchange, OH⁻ or Cl⁻ in the case of anion exchange) are weakly held to a resin containing fixed ions of opposite charge, and can readily be displaced by ions in wastewater with a greater affinity for the resin. Ion exchange is suitable for the removal of metals, nitrates, and sulfates.

11.1 PROCESS DESCRIPTION

Wastewater that has been pretreated to remove suspended solids and liquids is then passed through a bed of resin. The contaminants are exchanged onto the resin until the resin is fully loaded. The resin is then regenerated by washing it with a solution containing an excess of the

exchange ion. The contaminant ions are concentrated in the regeneration solution. In a typical system several beds are operated in series, with the first bed being taken out of service once it is loaded, and a regenerated bed is added to the last stage to maintain the number of beds.

11.2 DESIGN PARAMETERS

Resin type
Bed height (m)
Wastewater flow rate (m^3/d)
Inlet ion concentration (equivalents/L)
Inlet contaminant concentration (mg/L)
Outlet contaminant concentration (mg/L)
Pressure drop (cm water/m)
Cycle time (h)
Regeneration solution flow rate ($\text{L/s}\cdot\text{m}^2$)
Regeneration cycle time.

11.3 DESIGN MODELS

Laboratory or onsite small-diameter columns are used to determine full-scale design data. The design information required is surface loading rate and bed volume.

Generally the main criteria of concern are length of removal run, service flow rate, regenerate dose, flow rate, and concentration. The data collected to determine these criteria and to determine minimum required bed depth are saturation loading curves and elution curves. The development of these curves is discussed in the aforementioned references.

11.4 OTHER EFFECTS

Suspended solids--Clogs resin pores causing fouling and requiring a backwash.

Oil and grease--Can clog resin pores.

Strong oxidizing agents--Chlorine, nitric acid, chromic acid, hydrogen peroxide; and iron, copper, and manganese (in the presence of sufficient dissolved oxygen) will damage resins.

Certain organics--Some organics, such as aromatics, bind irreversibly to the resin causing deactivation.

Organic chemicals--Certain organic chemicals may dissolve and destroy resins.

Thermal stability--Resins are limited to about 60 °C maximum.

Species selectivity--Adsorption on one species may inhibit the adsorption of another species.

11.5 WASTE TREATABILITY DETERMINATION

Bench-scale batch equilibrium adsorption experiments are conducted using various types of resin to identify the most suitable resin. Bench-scale column tests are conducted using a system of three or more columns arranged in series with depth and flow rate in the range expected to determine the total bed depth and service time of a single column. Tests are also conducted to determine backwash requirements to remove suspended solids collected by the bed. Regeneration tests are conducted to determine regeneration requirements and to estimated resin degradation per each regeneration.

11.6 BIBLIOGRAPHY

- Mcardle, J. L. , M. Arozarena, and W. E. Gallagher, 1987, *A Handbook on Treatment of Hazardous Waste Leachate*, EPA/600/8-87/006, PIE Associates, Inc. for the U.S. Environmental Protection Agency, Cincinnati, Ohio.
- EPA, 1983, *Treatability Manual*, EPA-600/2-82-001, U.S. Environmental Protection Agency, Washington, D.C.

12.0 WET AIR OXIDATION

-- Wet air oxidation is a process in which dissolved or suspended oxygen-demanding components of a wastewater are oxidized at moderate temperatures and elevated pressures using an oxygen-containing gas such as air bubbling through the aqueous phase. The primary application of the process is for organic waste streams that are too dilute to incinerate and yet too toxic to biotreat. With most organic compounds, greater than 99% destruction is achieved. Chlorinated aromatics are the one class of compounds that is not easily destroyed by the process. Zimpro, Inc., has installed over 190 wet air oxidation units worldwide, primarily for treating municipal sludge.

12.1 PROCESS DESCRIPTION

The waste stream to be treated is pumped through a heat exchanger and into a reactor vessel. Depending on the material to be oxidized, the temperature ranges from 175 °C to 320 °C. Depending on the conversion temperature, the reactor is pressurized to 300 to 3,000 lbf/in² (gage). This pressurization is required to maintain the water as a liquid inside the reactor. An oxygen containing gas, usually air, is compressed and introduced into the bottom of the reactor. Organic compounds are converted to carbon dioxide and water. Organic sulfur is oxidized to sulfate, organic nitrogen

is converted to NH_3 , and NO_x or SO_x is formed. Metals generally are converted to their highest oxidation state and remain in the aqueous phase as dissolved or suspended solids. Halogens also stay in the aqueous phase.

12.2 DESIGN MODELS

Wet air oxidation is a chemical reaction and the rate of most reactions can be expressed as a function of temperature and composition. In practically all cases the temperature-dependent term can be well represented by Arrhenius' law:

$$k = k_0 e^{-E/RT}$$

where

k = the rate constant
 k_0 = the frequency factor
E = the activation energy.

Many elementary reactions are first order with respect to the reactants, and the rate equation can be integrated to the form

$$-\ln(1-XA) = kt$$

where

XA = the fractional conversion
t = the reaction time.

No information was found in the literature on the order or rate of reaction for wet air oxidation; however, there is extensive published literature on wet air oxidation and this information could be available.

12.3 DESIGN PARAMETERS

Temperature ($^{\circ}\text{C}$)
Pressure (kPa)
Residence time (h)
Oxygen/organic ratio.

12.4 OTHER EFFECTS

None were noted.

12.5 WASTE TREATABILITY DETERMINATION

A wide variety of organic materials have been tested and the results are available in the literature. If data on the specific organic compounds of

interest are not available, batch reactor tests in a bench-scale high-pressure autoclave would supply the necessary design information. Several tests would be required to determine the optimum temperature and the required residence time. Verification of this information in a continuous-flow reactor system should be done prior to design of the full-scale system. Facilities for both batch and continuous reactor tests are available at the CPDL at Pacific Northwest Laboratory.

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Dietrich, M. J., T. L. Randall, and P. J. Canney, 1985, "Wet Air Oxidation of Hazardous Organics in Wastewater," *Environmental Progress*, Vol. 4, No. 3, pp. 171-177.

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— Randall, T. L. and P. V. Knopp, 1980, "Detoxification of Specific Organic Substances by Wet Oxidation," *Journal Water Pollution Control Federation*, Vol. 52, No. 8, pp. 2117-2130.

13.0 INCINERATION

Incineration is a thermal process for destroying organic wastes in solid, gaseous, and liquid waste streams. Incineration is used to treat contaminated soils, sludges, activated carbon, aqueous streams containing more than 5% to 10% organics, and gaseous streams containing organic contaminants. Incineration processes produce a flue gas containing principally CO₂ and water with trace amounts of ash and other gases, and an ash that is rich in minerals and any heavy metals. Standard incinerator designs include rotary kilns, fluidized beds, multiple hearth incinerators, and liquid waste combustors. New technologies include plasma incinerators, molten salt combustors, and infrared systems.

13.1 PROCESS DESCRIPTION

Solid, liquid and gaseous waste streams enter a hot combustion chamber where the combustible components are volatilized and combusted with air at temperatures ranging from 600 °C to 1,650 °C. If there is insufficient combustible material in the waste to achieve the necessary temperatures, then an auxiliary fuel such as fuel oil is co-fired with the waste. Flue gas from the incinerator is usually scrubbed for NO_x, SO₂, HCl, and trace quantities of organic vapors and ash. The ash stream leaving the incinerator is quenched and subsequently disposed of by some form of landfill.

13.2 DESIGN PARAMETERS

Heating value of waste (cal/kg)
Moisture content (% of waste)
Ash content (% of waste)
Organic components
Key inorganic components (chlorine, sulfur)
Waste flow rate (kg/h)
Auxiliary fuel requirements (cal/kg)
Ash composition
Ash fusion temperature (°C)
Incinerator temperature (°C)
Solids residence time (h)
Gas residence time (h)
Flue gas composition
Liquid waste viscosity (cP).

13.3 DESIGN MODELS

The treatability of hazardous wastes by incineration is accomplished by pilot-scale tests. The parameters are selected for the tests to ensure that: there is sufficient oxygen in the combustion zone to accomplish complete combustion; there is sufficient turbulence in the incinerator between the waste and the air; and the combustion temperature and hazardous waste exposure time is sufficient to ensure adequate completion of combustion of the slowest reactant. These conditions are evaluated by varying the percent of excess air, waste feed rate, and supplemental fuel rate. Because the combustion rate generally follows first-order reaction kinetics according to the rate equation

$$RA = Ae^{(-E/RT)}$$

where

RA = the reaction rate
A = the frequency factor
E = the activation energy
R = the universal gas constant
T = the combustion temperature,

there is an inverse relationship between the combustion temperature that influences supplemental fuel requirements, and the time necessary for sufficient combustion, which influences the incinerator dimensions, for a given feed rate.

13.4 WASTE TREATABILITY DETERMINATION

Pilot tests are conducted using a candidate incinerator operating on barrel quantities of waste. Specific requirements are generally established by the vendor according to the number and duration of tests and the nominal capacity of the incinerator. These tests are evaluated to determine design parameters and to measure the destruction efficiency of the key contaminants, or a surrogate contaminant that is known to be more difficult to incinerate. Flue gases are evaluated to determine if products of incomplete combustion, such as CO, are too high, and whether other secondary products such as dioxins and furans are formed in quantities to be of concern. Fly ash and bottom ash are evaluated to determine the fate of any hazardous solid wastes, such as heavy metals. The characteristics of the gaseous and solid streams are used to determine subsequent treatment and disposal requirements.

13.5 BIBLIOGRAPHY

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- 0 EPA, 1983, *Treatability Manual*, EPA-600/2-82-001, U.S. Environmental Protection Agency, Washington, D.C.

14.0 BIOLOGICAL SUSPENDED GROWTH SYSTEMS

A suspended growth system is one in which the biomass (microbes) is maintained in suspension and in contact with the wastewater (substrate) by maintaining the proper mixing intensity. The process is typically used to remove organic material from an aqueous stream when maintained in an aerobic condition (with oxygen present). However, this type of treatment can also be effectively applied to the treatment of inorganic anions such as nitrates and sulfates. When used in this mode the process is operated in an anaerobic condition (lack of oxygen). Pilot-scale data have been reported for the application of this process on high concentrations of nitrate by the Oak Ridge National Laboratory. Both bench-scale and pilot-scale data for the treatment of nitrates are presently being developed by Pacific Northwest Laboratory in conjunction with the University of Washington.

14.1 PROCESS DESCRIPTION

The process consists of a mixed reactor that is open for aerobic systems (typically) and closed for anaerobic systems. Mixing is maintained by mechanical agitation. For the aerobic system, oxygen addition (typically using air) is required by either mechanical agitation or sparging. Anaerobic

systems require organic materials to serve as electron donors to reduce the inorganic constituent. Historically methanol or acetate have been used as the organic carbon sources for anaerobic systems. The reactor is normally followed by a clarifier that separates the biological solids from the treated water. The concentrated solids are recycled from the clarifier to the mixed reactor, a portion of which are wasted. The calcified effluent is then further treated or discharged. A brief aeration section between the two units is added for the anaerobic systems to enhance the settling characteristics of the biological solids.

14.2 DESIGN CRITERIA

Hydraulic detention time (h)

Biological retention time (d)

Influent concentrations (mg/L)

Effluent concentrations (mg/L)

Clarifier overflow rate (gal/d • ft²)

Solids flux rate (lb/d)

Temperature (°C).

14.3 DESIGN EQUATIONS

Substrate removal

$$S_e = K_s(1 + K_d \times \text{BSRT}) / [\text{BSRT}(Y_{t \times K_r} - K_d) - 1]$$

Solids yield

$$1/\text{BSRT} = [Y_{t \times K_r} \times S_o / (K_s + S_o)] - K_d.$$

14.4 WASTE TREATABILITY DETERMINATIONS

1. Set up five 3- to 5-L bench-top reactors.
2. With continuous waste feed to each reactor, maintain each reactor at a different BSRT.

3. Maintain same hydraulic detention time for all reactors (between 12 and 24 h depending on waste strength).
4. See reference given below for complete data analysis methods.

14.5 BIBLIOGRAPHY

Benefield, Larry D. and Clifford W. Randall, 1980, *Biological Process Design for Wastewater Treatment*, Prentice-Hall Inc., Englewood Cliffs, New Jersey.

0 1 1 7 0 3 2 2

APPENDIX G
DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

9 1 1 1 0 3 2 3

APPENDIX G

DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

4
2
3
0
1
7
9

The third phase of the feasibility study (FS) entails a detailed analysis of the alternatives to provide the decision-makers with sufficient information to select a remedy for the problems posed by the sites of the 1100-EM-1 operable unit. The steps required for this phase are shown graphically in Figure 7-1. The screened alternatives from the second phase of the FS and the results of treatability studies serve as the primary inputs to this phase of the FS. The alternatives may need revision due to the results of the treatability studies or additional information from the remedial investigation (RI). Each alternative will then be evaluated and compared to the others with respect to criteria established by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington Department of Ecology (Ecology). The results of the evaluation and comparative analysis will be presented in the feasibility report and will be used as the basis for selecting the alternative to be implemented. This report must provide sufficient information to support the evaluation of each alternative with respect to the selection criteria. The following describes the work required to complete the FS Phase III.

1.0 FURTHER DEFINITION OF ALTERNATIVES

Sufficient detail regarding the design of each of the alternatives must be developed to ensure adequate evaluation and comparison. The sizing of the facilities and the inclusion of all significant support facilities are among these design details. Details regarding the site characteristics and any assumptions regarding the remediation requirements must also be commonly applied in the development of each alternative. As noted previously, the data input to this phase of the FS is primarily from treatability studies. The analysis of the data serves to further define the alternatives for full-scale conceptual design.

1.1 ANALYSIS OF TREATABILITY STUDY RESULTS

Data generated by treatability studies must be evaluated to determine the effectiveness and implementability of the proposed treatment or remediation methods. The evaluation may include statistical analyses to establish confidence limits for performance. The evaluation is intended to establish how the treatment method will perform as an applied process. Information necessary to design facilities to implement the treatment method may also be derived from the study results. Specific evaluation methods consistent with the needs of the feasibility study will be determined based on the treatability studies conducted.

1.2 FULL-SCALE CONCEPTUAL DESIGN

Full-scale conceptual designs for each alternative will be developed based on the remediation needs of the 1100-EM operable unit and the capabilities of each remediation method. The RI and earlier phases of the FS will provide the determination of remediation needs for the sites. The treatability studies will provide the remaining information necessary to estimate the efficiencies and limitations for each remediation method. To develop appropriate conceptual designs, analyses such as the following may be required for each alternative.

- Perform mass balance and energy balance analyses.
- Calculate sizes of unit processes.
- Identify and size all supporting appurtenances.

Specific design requirements and the associated appropriate analyses will be determined based on each individual alternative.

2.0 ANALYSES REQUIRED FOR EVALUATION OF THE ALTERNATIVES

The selection of an alternative for implementation will be dependent on the comparative performance of each alternative. Prior to conducting comparative analyses, evaluation criteria must be established, sufficient information must be generated to evaluate each alternative for each of the criteria, and the performance of each alternative with respect to each of the criteria must be evaluated.

2.1 EVALUATION CRITERIA

Criteria for evaluating the alternatives will need to be developed and approved by the DOE, EPA, and Ecology. The environmental and public health concerns posed by the 1100-EM-1 operable unit must be thoroughly addressed by these criteria in addition to other considerations. The most current criteria proposed by the EPA for application at Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) sites are described in draft guidance for conducting remedial investigations and feasibility studies under CERCLA. These criteria will serve as the basis for the criteria to be developed for application at the 1100-EM-1 operable unit. They are as follows:

- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Compliance with applicable or relevant and appropriate requirements (ARAR)

- Overall protection of human health and the environment
- Implementability
- Cost
- Acceptance by the state regulatory agencies
- Acceptance by the community.

Subsequent work of the third phase of the FS is directed toward providing sufficient information to support evaluation of each alternative for each of the criteria. The identified criteria were used as the basis for defining subsequent work in this work plan. Revisions to this work may be necessary when the final criteria are determined.

2.2 PERFORMANCE ASSESSMENT ANALYSIS

The performance of each alternative will be assessed using the models developed in earlier phases of the FS. These assessments must address the following criteria:

- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Compliance with ARARs
- Overall protection of human health and the environment.

The assessment analyses must be carefully designed and conducted to provide an adequate basis for evaluating the remedial alternatives with regard to each of these criteria.

2.3 IMPLEMENTABILITY ANALYSES

The alternatives will also be evaluated with regard to a criterion defined as implementability. This evaluation entails an assessment of the technical and administrative feasibility for each alternative. It also entails an evaluation of available resources with respect to those required to implement each alternative.

2.4 ENGINEERING COST ANALYSES

Estimates of the costs associated with each alternative must be developed. Among the costs that will be estimated are the following:

- Capital costs
 - Equipment
 - Construction
 - Labor
- Operating costs
 - Material and energy
 - Labor
- Maintenance costs
 - Material
 - Labor.

These costs must also be analyzed in a variety of ways:

- Cost-sensitivity analyses
- Present worth analysis
 - Total life-cycle cost
- Accuracy of cost estimates determination.

These cost analyses will provide a common basis for comparing the alternatives with respect to costs.

2.5 ANALYSIS OF PUBLIC ACCEPTANCE

State and community acceptance of the alternatives will be evaluated to the extent possible on the basis of information available at the time the FS report is being written. Because the information regarding these two criteria may be limited, they may not be fully evaluated until a final decision is being made and the record of decision is being prepared.

2.6 COMPARATIVE ANALYSIS

The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative relative to the others. The individual analyses conducted for the alternatives for each of the nine criteria serve as the basis for the comparative analysis. The performance of the alternatives with regard to each of the criteria is compared and evaluated. The analysis will serve to distinguish each of the alternatives from the others based on the associated costs and benefits.

2.7 FEASIBILITY STUDY REPORT

The FS report will present the results of the detailed analyses of the alternatives. The report will include a narrative discussion of the strengths and weaknesses of each alternative with respect to the criteria and each other. Differences between alternatives that can be measured either qualitatively or quantitatively will be identified. Guidance regarding the content and format of this report is provided in draft guidance for conducting remedial investigations and feasibility studies under CERCLA. The process of issuing a final version of the report will include revisions based on reviews by the EPA, Ecology, and the public.

2.8 REFERENCES

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, Public Law 96-510, 94 Stat. 2767, 42 USC 9601 et seq.

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